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Trade and Development

Proceedings of the Winter 1986 Meeting of the International Agricultural Trade Research Consortium

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ABSTRACT

Trade is both a driving force for economic growth and economic growth is a major determinant of agricultural trade. This meeting was held at the International Wheat and Maize Research Center (CIMMYT) in Mexico and focused on how trade and economic development are related. Three separate sections comprise the set of papers presented at the meeting. The first, representing the theme day, involved four papers focusing on the relationship between trade and development. The second focused on CIMMYT's role in generating agricultural development through the transfer of high yielding wheat varieties to Third World countries. The third presented a set of short related papers are presented on a variety of topics of current interest.

Keywords: Agricultural development, agricultural trade, economic growth, trade liberalization, international agricultural research, technical transfer

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PREFACE

This report contains papers presented at the December 1986 meeting of the International Agricultural Trade Research Consortium (IATRC) at the Headquarters of the International Maize and Wheat Improvement Center (CIMMYT) in Texcoco outside of Mexico City. The theme of the meeting was the relationship between trade and development. This issue is currently being hotly debated and at its core is the underlying rationale for stimulating development efforts in Third World countries.[1] The objective of the meeting was to focus on issues relating to trade and development in both a broad and narrow context. The special opportunity to hold the meeting at CIMMYT Headquarters in Mexico is much appreciated and the inclusion of a section on CIMMYT's role in world agricultural development is the consequence.

A number of individuals cooperated to make this program possible. Co-chairmen and organizers of the theme day program were Mathew Shane of the Economic Research Service (ERS) and Scott Pearson of Stanford's Food Research Institute. T. Kelley White of ERS was the overall program coordinator. James Longmire of CIMMYT was responsible for programming the entire logistical support for the meeting as well as organizing the CIMMYT part of the program. Mathew Shane served as overall editor for this volume.

There are three levels of papers presented at this proceedings. This reflects, in a sense, the organization of the meeting. The first set is full research papers presented during the theme day of the meeting. A second set of papers represents material taken from transcriptions of the presentations to the meetings. A set of shorter summaries of presentations is included in Section IV. Three of the papers, the one by Srinivasan, Winkleman, and Borlaug, are based on papers that were first presented and developed for other purposes.

IATRC is a group consisting of government and university researchers in the United States, Canada, Europe, and Australia who come together twice a year to focus on important issues affecting the world's agricultural economy.[2] The ability to bring together a relatively small group of researchers with common interests and concerns has proven to be a successful forum for discussion and debate on critical international trade issues.

The goal of increased interaction between ERS and U.S. university researchers was formalized in June 1980 by establishing the Consortium on Trade Research. USDA's Foreign Agricultural Service (FAS) joined the consortium in 1982. Membership in the consortium has subsequently expanded to include further institutional membership such as Agriculture Canada and the Bureau of Resource and Agricultural Economics of Australia, as well as researchers from Canada, Germany, France, Australia, and most recently Poland. The more formal establishment of the IATRC took place in 1985. The objectives of the consortium are to:

- Foster sustained efforts in international agricultural trade research.
- Encourage and facilitate interaction between ERS, FAS, and U.S. university and foreign trade policy researchers.

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[1]For some recent conferences focusing on U.S. interests in Third World development, see: Randall B. Purcell and Elizabeth Morrison (eds.). U.S. Agriculture and Third World Development: The Critical Linkage, Lynne Rienner Publisher, Boulder, Colorado, 1987; and Food and Agricultural Committee. U.S. Agriculture and Third World Economic Development: Critical Interdependency, National Planning Association, Washington, DC, February 1987.

[2]For a history of the IATRC and organization details, see: The International Agricultural Trade Research Consortium - Origins, Objectives, Organization, Operation, and Program Plan for 1985-87, Executive Committee of IATRC, unpublished paper, Agricultural Economics Dept., University of California, Davis, June 1, 1985.

- Provide a forum for exchanging research results and aid in identifying problem policy issues requiring research.

The consortium is a cooperative undertaking between ERS, FAS, various U.S. universities, Agriculture Canada, and Canadian universities. Membership in the consortium is subject to approval by the consortium's executive committee, but is generally open to those in international agricultural trade research and analysis or its policy applications.

Mathew Shane

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INTRODUCTION

Mathew Shane[1]

The linkages between international trade and economic development are among the most important both for the trade analyst and for the development economist. For the trade analyst, it is the gains from trade that can be used to generate a sustained growth pattern, while for the development economist, it is the transformation in consumption patterns over the development process that is a prime factor for generating the demands for a broad range of imports. The linkages between trade and development and development and trade lead into some of the major issues dealt with by both trade and development economists. Thus, the trade and development linkage leads into issues of technical transfer, international capital markets, direct investment, and international borrowing, while the development and trade linkage leads into issues of aid and trade, exporter interest in economic development, and the entire issue of trade liberalization.

The relationship between trade and economic development has become even more important in recent years because of the increased openness of the world economy. With the exception of only a few years, trade has grown more rapidly than gross national product (GNP) over the post World War II period. This pattern was even more pronounced during the sixties and seventies. Thus, the United States increased its trade share of GNP from 10 percent to about 20 percent during this period. Even more fundamental is that countries such as South Korea and Taiwan have dramatically increased their export shares, while the lagging economies of Africa have followed self-sufficiency policies and reduced their exposure to trade.

In spite of the importance of this subject, very few serious efforts have been undertaken to analyze these linkages. This proceedings was designed to begin to systematically explore this important subject for economists, trade researchers, and policymakers. The proceedings is divided into three sections.

Section I. Trade and Development

The paper by T. N. Srinivasan provides a broad survey of the literature on the impacts of trade and development. In particular, he looks at all of the arguments under which the classical assumptions are violated. His conclusion "that countries that followed an outward-oriented strategy not only did better by most indicators of development, but also weathered better the shocks to the world economy" set the framework for the meeting.

The paper by Terry Roe and Mathew Shane on the role of "Governments in the Process of Trade and Development" explores the reasons for government interventions and the basis for endogenizing such interventions in development modeling.

Robert Herdt looks at the "Technological Potential for Increasing Crop Productivity in Developing Countries." He concludes that in the short to intermediate term, there is not much prospect for future substantial productivity gains based on existing technology.

Per Pinstrup-Andersen focuses on the "Changing Patterns of Consumption Underlying Changes in Trade and Agricultural Development" involved in the development process. His conclusion that there is a "strong relationship between consumption patterns and incomes at both the national and household levels" provides the foundation for the argument that development is the driving force for increased import demand.

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[1]The author is an economist, Agriculture and Trade Analysis Division, Economic Research Service, U.S. Department of Agriculture, Washington, DC.

Lucio Reca's paper on "An Argentine Perspective on Recent Agricultural Trade and Policy Development" provides a refreshing and dramatically different view of our current world situation. His conclusion that "the present situation in world agricultural markets could well be characterized as economically irrational, politically selfish, and ethically unacceptable" is a strong statement that might reflect the sentiment of most of the Third World.

Mathew Shane's brief paper summarizes the theme of this conference by looking at the basic linkages from outward-orientation to development and from development to import demand as the basic mechanism by which growth takes place in both trade and development. His conclusion that "that current world environment in which both trade and income growth are lagging is very poor environment to stimulate development" points out the basic contradiction facing the international economy. If trade is the main engine of development and if development is the main stimulus to import demand growth and there is not much of either, what development and trade strategy should now be pursued?

Section II. CIMMYT's Role in World Agricultural Development

The section on International Maize and Wheat Improvement Center (CIMMYT) provides a perspective of how the international centers facilitated the transfer of technology to further agricultural development around the world. The four papers provide us with a broad view of CIMMYT's role historically and perspectives for the future.

Section III. Special Issues in Trade and Development

This section presents short summaries of presentations based on current ongoing research on critical international issues. The 10 papers largely focus on trade liberalization issues.

TRADE AND DEVELOPMENT

INTERNATIONAL TRADE AND FACTOR MOVEMENTS IN DEVELOPMENT THEORY, POLICY, AND EXPERIENCE[1]

T. N. Srinivasan[2]

Introduction

The role of international trade and factor movements in the process of economic development of developing countries (LDC's) has continued to attract the attention of economic theorists, policymakers, and chroniclers of economic development. While it is too much to expect a consensus view of this role to emerge based on the confrontation of alternative theories with the development experience of many countries since the Second World War, it is fair to say that (1) the divergence of views has narrowed and (2) the proponents of alternative views are able to support them by drawing upon (albeit selectively) an impressive accumulation of analytical and empirical studies.

The past 25 years have witnessed a sea-change in the world economic system: the nations of the world have become more interdependent both in the sense that a larger proportion of world output is traded in world markets and that world capital markets have become integrated to a considerable extent. The system has absorbed significant shocks: the collapse of the Brettonwoods system of fixed exchange rates, the two massive oil price increase in 1973 and 1979, the related phenomena of recessions in industrialized countries, and the unprecedented increase in real interest rates. Whether the recent fall in oil prices and interest rates will sustain the ongoing recovery and help the oil importers or whether it will end it through its effect on some oil exporting countries (mainly the heavily indebted ones) and the capital exporters is too soon to tell. Be that as it may, the experiences of countries that followed development strategies with different foreign trade orientation in adjusting to external economic shocks provide an unusual opportunity for assessing the strengths and weakness of the strategies pursued.

Since the Second World War, we witnessed several rounds of multilateral negotiations and agreements for reducing the tariff and nontariff barriers to international trade. Numerous innovations in reducing political and other risks involved in foreign investment have also taken place. Also, a set of proposals for a New International Economic Order (NIEO) was put forward by the developing countries in the second half of the seventies. The so-called North-South negotiations between the developed (north) and developing (south) countries on these proposals have been held off and on since then. While a few of these proposals were accepted by the north in some diluted form, all of them have been the subject of a number of studies, which by and large conclude that most developing countries were unlikely to benefit from the proposals, if they benefit at all. For all intents and purposes, these proposals are dead, if not yet buried.

Beside the shocks and shifts in the global economic system of the past 25 years, there have also been significant additions to the analytical toolkit of economists in general and development economists in particular. Some of the analytical problems that were once thought to be peculiar to development economics have now become part of the mainstream. Advances in economic theory, in particular, the attempts to provide a more satisfactory

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[1]This paper with minor editorial changes is a reprint of the same titled paper in P. Schultz and G. Rains (eds.), The State of Development Economics: Progress and Perspectives published by Basil Blackwell. We appreciate the permission of the publisher, author, and editors to reprint this article.

[2]The author is the Samuel C. Park, Jr., Professor of Economics, Department of Economics, Economic Growth Center, Yale University, Hartford, CN. I thank Bela Balassa, Willem Buiter, Michael Jones, Kenneth Kletzer, Pradeep Mitra, and Gustav Ranis for their valuable comments on an earlier draft.

theory of expectation formations and (microeconomic) foundations for macroeconomics; the development of models incorporating features of industrial organization theory in analyzing problems of international trade; and analysis of the implications of viewing nonmarket institutions and processes as serving the functions of nonexistent or imperfectly functioning markets in a context of asymmetric information, moral hazard, and adverse selection have all influenced development theorizing. There has been an enormous increase in the quantity (if not to the same extent in the quality) of economic data on developing countries. At the same time, a vast array of new econometric tools and the computational capacity to use them have become available, enabling analysts to use simulation with empirical models as a technique for understanding the implications of complex policy scenarios and shocks to the system. This is a task that is not easy to accomplish only with a priori theorizing even of the most sophisticated kind.

The developments in the world economy, in empirically modeling, the functions of the economic system, and simulating the effects of counter-factual policy variants and other shocks to the system have been substantial. It is impossible to discuss them in a coherent manner in one paper, even if one were, indeed, equipped to do so. I took a more modest approach and reviewed only a few theoretical advances and empirical studies relating to international trade and factor movements.

The Foreign Sector in Development Strategy

Foreign trade has been viewed as a lead sector in development strategy for some time. The perception of the role of trade has changed over time.

Early Perceptions and Subsequent Experience

It is useful to begin with some facts at the aggregate level. Contrary to the widespread belief in the immediate post-World War II years that the prospects were dim for substantial growth in world trade and of per capita income of the poor countries, the realized growth was remarkable. However, it is too soon to assess whether the growth path of the pre-first-oil-shock period has been restored since 1984 (tables 1 and 2). The realized average growth rate of per capita income over 1950-83 at about 3 percent per annum exceeded by a third the growth rate achieved by most of today's industrialized countries over the century ending in 1960. Equally, if not more impressive, is the fact that the volume of world trade as a whole grew faster than world gross domestic product (GDP). Trade in primary products (agriculture and mineral) seems to have grown faster than the growth in their output. This aggregate picture masks substantial variations among countries and, in part, can be explained by their policies. Nevertheless, the pessimistic perspective on the elasticity of trade with respect to output and income that colored early development theorizing and policymaking has been clearly belied by history.

This pessimism led to the identification of a shortage of foreign exchange as one of the key (if not the sole) constraints on economic development. Cairncross put the dominant view succinctly: "The majority of the underdeveloped countries are monocultures, dependent for their earnings of foreign exchange on a single commodity (or at most two or three). These earnings are highly inelastic except when exports of the principal commodity form a small fraction of the world's consumption. At the same time, nearly all the plant and machinery that they require has to be imported, so that the scale of industrial development is limited by the foreign exchange available to pay for it" (22)[3]. It is indeed ironic that this view of a single primary commodity export with (income) inelastic foreign demand

[3]Underscored numbers in parentheses are listed in the References at the end of this article.

Table 1--Growth of world merchandise trade and production

Item	Annual rate of change		
	1963-73	1973-83	1984
Exports:		Percent	
All merchandise	9.0	3.0	9.0
Agricultural products	4.0	3.0	7.0
Minerals	7.5	-2.0	3.0
Manufacturers	11.5	4.5	12.0
Production:			
All merchandise	6.0	2.0	5.5
Agriculture	2.5	2.0	5.0
Minerals	5.5	0.5	2.0
Manufacturing	7.5	2.5	7.5
Share of developing countries:	1963	1973	1984
In world exports	20.5	19.0	24.5
In world imports	21.0	18.0	23.5

Source: (30, pp. 4-6).

Table 2--Growth of per capita real gross domestic product

Item	1955-70	1965-73	1973-80	1981	1982	1983	1984 1/	1985 2/
			Annual rate of growth					
All developing countries	3.1	4.1	3.2	1.0	-0.7	0	3.3	2.4
Low-income countries	1.6	3.0	2.7	3.0	3.2	6.1	7.4	6.1
Major exporters of manufactures	3.9	4.6	3.1	-.8	-2.0	-1.6	1.8	1.0
Oil importers	3.2	..	..	..	..	..	..	..
Oil exporters	3.4	4.6	3.4	1.5	-2.8	-4.4	.7	0
High-income oil exporters	5.8	4.1	5.9	-.7	-7.6	-15.7	-3.0	-8.5
Industrial market economies	3.6	3.7	2.1	-1.1	-1.3	1.6	3.9	2.4

.. = Not available
1/ Projected on the basis of GDP.
2/ Estimated.
Source: (75, table 3.1 for 1982 and; table A.2 for 1986).

constraining the imports of capital goods needed (often in fixed proportion to output) for industrial development continues to underpin some of the recent structuralist North-South models. This suggests that some form of theorizing is unlikely to be influenced by inconvenient facts.

Evolution of Analytical Models: Two Gaps to Applied General Equilibrium

The early development models of (Chenery and Bruno, Chenery and Strout) encapsulated a rigid foreign exchange gap (in addition to a domestic savings gap) that can prove to be a binding constraint on development, given the assumed exogeneity of export earnings (24, 25). When the exchange gap was binding, which implied that there was a realizable but unrealized pool of domestic savings, foreign aid became twice blessed, once for relieving the constraint on imports of capital goods and once again by realizing the potential domestic savings and converting it (together with aid financed equipment imports) into productive capacity in the form of plant and equipment.

In time, the two-gap models begat a generation of multisector development planning models. The analytics of these models were summarized by Blitzer, Clark, and Taylor (18). Some limited input substitution in production was included in these models in the form of alternative activities that used inputs in different but fixed proportions. Even more limited commodity substitution in demand was allowed in an ad hoc way.

The choice among alternative production and consumption activities was the consequence of the optimization of the specified objective functions of these models. Put in another way, their choice was not necessarily the result of the response of producers, consumers, and traders to the relevant prices and constraints faced by them. It was as if these agents faced the "shadow prices" associated with the "optimum" solution to the model, and their actual decision environment was adequately described in the model.

Implicit in this was also the belief, though not necessarily shared by all modelers, that the planner (such as, the state) had enough fiscal and other instruments in his arsenal to assure that the "shadow prices" were in fact the actual prices faced by consumers and producers. Thus, a purposive planner, imbued with the long-term interests of the society, having an appropriately formulated model of the economy, was supposed to use the model as a tool to analyze the implications of alternative strategies and policies and arrive at the most suitable (if not the optimal) strategy together with a description of taxes, subsidies, and other items needed to implement the strategy. It must be added, however, that the more perceptive planners did not share this view of the modeling exercise. They viewed the models only as a computationally convenient but necessarily rough approximations, which were far more useful than other methods to check the internal consistency of alternative plan proposals. They rightly believed that the planning models cannot eliminate the role of judgment in making hard political and socioeconomic choices. Forgetting this important fact can lead to unfortunate consequences. For example, Rosen (56) provides a fascinating account of the entanglement in Indian politics of a, in many ways, pioneering, planning model put together in the sixties by Indian and foreign economists working for the Center for International Studies at Massachusetts Institute of Technology (MIT).

The capacity to build an empirical analogue of a price-endogenous Walrasian General Equilibrium Model (WGEM) and algorithms to compute its equilibrium became available in the midseventies. This new model of applied general equilibrium analysis was quickly put to use for analyzing domestic fiscal policies in a number of countries by Shoven Whalley (61). Their multicountry variants have been used to analyze foreign trade policies, particularly unilateral and multilateral trade liberalization. Such models have been put together for several developing countries, largely under the sponsorship of the World Bank. At the International Institute for Applied Systems Analysis (IIASA) in Austria, a model was prepared from the pioneering effort of Adelman and Robinson (1).[4]

The attractions of such a model are obvious enough: not only the allocative efficiency implications of policies that distort the equilibrium set of market prices can be analysed, but through their effect on equilibrium returns to primary factors, the income distributional implications can be drawn as well. Provided one is willing to specify the processes of formation of price expectations, accumulation of primary factors and of technical change, a sequence (in time) of equilibria can be computed as well. Elements of such a sequence are not, of course, components of an intertemporal competitive equilibrium but simply of Hicksian temporary equilibria. Thus, static as well as dynamic efficiency and equity implications of alternative development strategies could be analyzed or so it was hoped. Clive Bell and I critically examined the strengths and weaknesses of such models for understanding the development processes (6). These models have been far more useful in examining issues of allocation and efficiency than as tools for analyzing processes.

The evolution of another useful tool, namely, social cost benefit analysis, for analyzing choice at the sectoral and project level rather than at the economy-wide level needs to be

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[4]It is interesting that the earliest empirical planning model for any developing country was by Sandee (60) for India. However, a price endogenous model for India came years after Adelman and Robinson's for Korea, as if the attitudes of policymakers toward prices and markets in the two countries influenced the modelers (1).

briefly noted. Cost benefit analysis as a tool for making public investment choice is not a new development. Its refinement, however, to incorporate a wide spectrum of social objectives (including those relating to the distribution of income along socioeconomic groups at a point in time and over time) and the derivation of procedures for the evaluation of individual projects from an explicit or implicit economy-wide model indeed are new. Such derivation can be linked to the evolution of economy-wide models. Simply stated, the problem of project evaluation is to arrive at a set of social or shadow prices to inputs and outputs of a project during its lifetime so that the net present value of the project at these prices indicates its social-welfare impact. Analogous to the use of simple models such as the two-gap model, there were attempts to derive shadow pricing formulas for a few key factors such as unskilled labor, capital, and foreign exchange. As the simple one and two sector models evolved into multisector, multiperiod programming variants, the shadow prices for inputs and outputs associated with the optimum solution to the economy-wide programming problem suggested themselves as the relevant ones for use in project evaluation. Unfortunately, apart from the conceptual problem that each ad hoc constraint introduced to approximate some aspect of reality, the programming model acquired a shadow price that was not easily interpretable and usable in a project evaluation context.

As it turned out, the shadow price vector was not very robust even to minor changes in the specification of the model. By viewing a project as a small perturbation of an initial equilibrium, one could derive project evaluation criteria from the applied general equilibrium models as well. The same robustness problem with respect to model specification arises in this case also. Workable procedures of evaluation have to be robust, theoretically sound, and simple in computation. The two basic project evaluation guidebooks emerged from a search for workable procedures, namely, the OECD manual authored by Little and Mirrlees (46) and the UNIDO guidelines authored by Dasgupta, Marglin, and Sen (26). A central result of these manuals is that for a small open economy (that is an economy that cannot influence the relative prices of internationally traded goods) shadow prices for traded goods are their "border" prices (that is, f.o.b. prices for exports and c.i.f. prices for imports). The shadow prices for nontraded goods and primary factors can often be derived from traded goods prices. These results are fairly robust (as long as the economy is a price taker in world markets and distortions are not due to quantitative interventions, such as import quotas) and can be rigorously derived from a general equilibrium model of the economy (62); thus, making the procedure theoretically sound. Since border prices for traded goods are readily available and the procedure for deriving other prices usually requires no more than an input-output table, the procedure is easily implemented.

Outward- and Inward-Oriented Development Strategies

The early pessimism with respect to foreign demand for exports was partially based on the dismal experience with foreign trade during the inter-war period in general and the depression period in particular. This pessimism, apart from its impact on analytical modeling of development, was a major reason for many developing countries to adopt an "inward-oriented" strategy of development in spite of the potential static and dynamic gains of an "outward-oriented" strategy. To avoid the misidentification of outward orientation either with active export promotion or with laissez-faire, let me define an outward-oriented strategy as one that has no significant bias, first toward autarkic development, or second toward either export promotion (earning of foreign exchange) or import substitution (saving of foreign exchange). Many countries adopted a development strategy that was biased toward import substitution (beyond what would occur if dictates of comparative advantages were followed). They also implemented it through a regime of quantitative restrictions on imports and exports of goods and services, domestic and foreign investment, and imports of technology. Tariffs and price interventions were not altogether absent. The failure of this strategy was becoming clear by the midsixties. Although few countries abandoned it altogether, several countries experimented with

liberalizing their foreign trade and payments regimes. These liberalization episodes as well as the claims of rapid industrialization (enhanced investment rates, greater employment creation, and faster technical progress made in favor of the inward-oriented strategy) were examined in a number of theoretical and empirical studies in the late seventies (2,9,16,41,42).

Very few of the claims made for inward orientation were supported by the experience of the countries studied. The strong conclusion emerging from these studies is simply that trade liberalization is beneficial and the performance of countries that either switched to, or pursued from early on, a version of the outward-oriented strategy far outstripped that of others. Bhagwati persuasively argues that the attribution of success of the outward-oriented strategy for eastern countries (such as Singapore, Taiwan, and South Korea) to their authoritarian regimes is simply an assertion without any convincing evidence to support it (11).

An apparently unfavorable assessment of outward orientation emerges from studies of trade liberalization, using the newer tool of applied general equilibrium modeling. Whalley (73) and Srinivasan and Whalley (65) report on several of these studies. Since the results of most studies are similar, let me draw on Whalley (73) for illustration. His model distinguishes seven regions: the United States, EC, Japan, other developed countries (ODC), Organization of Petroleum Exporting Countries (OPEC), newly industrializing countries (NIC's), and less developed countries (LDC). Six aggregate products are produced in each region with five of them being internationally traded. He makes four counter-factual simulations or scenarios. He included in the first scenario only the northern regions (United States, EC, Japan; and ODC), in the second scenario only the southern regions (OPEC, NIC's and LDC), and in the third scenario, all seven regions abolished tariff and nontariff barriers. In the fourth scenario, the southern regions grew faster in the post-1978 period than the northern regions did in the pre-1978 period. The welfare impact of liberalization is assessed by Hicksian Equivalent Variation of income. The results are shown in table 3.

The global gains to trade liberalization are extremely modest, varying from 0.28 percent of 1977 GNP in scenarios 1 and 2 to 0.36 percent in scenario 3 when the whole world achieves the Nirvana of free trade. The NIC's-LDC group lose almost 5 percent of their GDP by unilaterally liberalizing and about 4 percent when the rest of the world joins them in liberalizing. As in scenario 4, if the southern regions continue to grow faster and attempt to catch up with the northern regions, their terms of trade deteriorate. Should we conclude from this that outward orientation makes only a marginal difference to world welfare but definitely harms the LDC's and NIC's?

I argued elsewhere that such a conclusion would be wrong for several reasons (64). These reasons include the competitive general equilibrium features of the models, particularly their inadequacy in capturing the necessarily forward-looking and dynamic processes of factor accumulation and technical change, and their manipulation of data (as well as the specification of crucial elasticity parameters) to make them an internally consistent equilibrium set. I wish to emphasize two features that are likely to understate the gains from outward orientation in developing countries. The first relates to the fact that the models assume rent-seeking activities triggered by policy instruments used in implementing an inward-oriented strategy. Such rent seeking diverts resources away from producing goods and services demanded by final consumers, a diversion that will by definition disappear with liberalization. The second is the assumption that production takes place under constant returns to scale technologies and competitive market structures. Yet, the policies (particularly those relating to the industrial sector such as investment licensing and allocation of capital goods imports) used to sustain inward orientation restrict competition not only from imports but also among domestic producers. In fact, they create domestic oligopolies and even monopolies besides establishing high-cost domestic capacity of nonoptimal scale for the production of import substitutes. Again, gains from

Table 3--Welfare impact of trade liberalization secnarios and terms-of-trade impact of differential growth

Region	Gross national product	Scenario		
		1	2	3
	Billion 1977 dollars	- - - - - - - - Percent - - - - - - - -		
EC	1,629	-3.1	37.2	33.1
United States	1,897	-.1	12.1	10.7
Japan	734	-.1	12.1	10.7
ODC	2,024	3.4	4.5	5.6
OPEC	303	1.7	7.0	4.4
NIC's	461	9.2	-31.6	-24.3
LDC	773	11.8	-28.2	-23.0
World	7,824	22.1	22.0	27.8

	Annual growth rate	Terms-of-trade change relative to base case		
		After 5 years	After 10 years	After 20 years
		Percent		
EC	3.3	3.4	6.8	13.9
United States	2.8	3.4	6.9	14.0
Japan	4.8	-3.4	-6.7	-13.1
ODC	4.1	-2.8	-5.7	-11.1
OPEC	3.5	.9	1.8	3.5
NIC's	5.2	-4.6	-8.9	-17.2
LDC	4.5	-3.1	-6.1	-12.1

Source: (72, tables 4 and 5).

liberalization arising from the elimination of deadweight losses due to imperfect competition are not captured by the models.

There are two studies that estimate the gains from liberalizing an economy in which rent seeking or imperfect competition is prevalent. The first by Grais, Demelo, and Urata models the rent seeking associated with import quotas in the Turkish economy (31). It finds that while the gain to the removal of tariffs only (while keeping the quotas intact) was negligible, the removal of quotas increased real GDP compared with its base or reference value between 5 and 10 percent. The second study by Harris was on Canada's economies of scale and imperfect competition (33). He found that Canada's participation in a multilateral reduction of all tariffs yield a welfare gain in excess of 5 percent of GNP.

Outward Orientation and Adjustment to External Shocks

In the literature on the role of international trade and development, it is sometimes argued that outward orientation may expose a developing economy to disturbances that have their origins elsewhere in the trading world. In particular, a small open economy engaging in free trade (and capital movements) will be exposing itself to uncertain terms of trade (and interest rates). Of course if the small open economy faces a complete set of contingent commodity markets in the Arrow-Debreu sense, the argument in favor of the optimality of free trade is unaffected. But in the real world of incomplete markets, a general answer as to the expected welfare impact of trade restrictions cannot be given. However, to the extent that uncertainties can originate in the home economy as well as the

rest of the world, opening the economy to foreign trade offers insurance against risks originating at home. For example, the ability to import from the rest-of-the-world reduces the risk associated with crop failures at home as long as such failures are not correlated with those abroad.

The problem of adjustment to shocks should be conceptually distinguished from the issue of whether or not to trade in a world in which the exogenous variables of an economy (such as its terms of trade, if it is a small open economy) are uncertain but have a known objective or perceived probability distribution. One definition of an external shock, though not a universally accepted one, is that it is an unanticipated, temporary or permanent, change in (the joint probability distribution) of one or more exogenous variables to the economy. Adjustment to a shock then can be defined as changes in the time path of endogenous variables, in particular, policy instruments that are occasioned by the shock. Given some indicator of the cost of adjustment, one could compare alternative policy responses to the shock. The development strategy pursued by a country will affect its adjustment process. One strategy as compared with another may expand the set of feasible policy responses to a given shock and, as such, will be better from the point of view of adjustment regardless of how the cost of adjustment is defined. Even if such a strong ranking of two strategies is not always possible, one can compare them given an indicator of adjustment costs.

One could view, as Neary did in his lucid analysis, the problem of adjustment as tracing the consequences of an exogenous shock to an initial (steady state) equilibrium of an economy until a new equilibrium is reached (52). Loosely speaking, the process by which the economy reaches a new equilibrium once it is out of an initial equilibrium can be specified in alternative ways depending on the flexibility with which resources move between sectors, the time horizon involved, and the policy instruments used to influence the process. Again as Neary argues, while conceptually such an analysis is appealing, the fact that in the real world the economy is likely to be bombarded by a sequence of shocks, each one coming before the adjustment to all the earlier ones have completely worked themselves out, makes analysis of the efficacy and welfare cost of particular policy interventions or of development strategies in the adjustment process particularly difficult.

A number of studies at the World Bank by Balassa (2,3,4,5) and Mitra (50,51) view the OPEC induced increase in real oil prices of 1973 and 1979 and the increase in real interest costs of international borrowing in the early eighties as shocks. They attempt to quantify these shocks as they affect different countries and compare their adjustment policies in terms of certain indicators. Balassa concludes from such a comparison that developing countries pursuing an outward-oriented development strategy were more successful in their adjustment. While this is in many ways a comforting conclusion, there are some problems with the approach that is used in arriving at such a conclusion.

Balassa defines adjustment policies as responses to external (or internal) shocks that have as their objective the regaining of the pre-shock growth path of the national economy. Such a definition presumes that regaining the pre-shock growth path is not only feasible but also optimal in the sense of minimizing the costs (or maximizing the gains, in the case of favorable shocks) of adjustment. Although Balassa's definition of external shocks as "unanticipated changes in world economic conditions" is not too different from the definition given above, his methodology of quantifying shocks involves the assumption of static expectations. Thus, any difference in a country's average terms of trade during the shock-adjustment periods (1974-78 and 1979-83) compared with the average during the immediate pre-shock periods (1971-73 and 1976-78) is viewed as the magnitude of a terms-of-trade shock. Similarly, the difference between the average interest rates during 1976-78 and the average during 1979-83 is viewed as the magnitude of an interest rate shock. The magnitude of the shock to foreign demand for a country's export is identified as any deviation from its pre-shock share in the trend value of world exports. It is not easy to specify the anticipated or expected path (or more precisely the stochastic process)

of the exogenous variables so that departures from it could be deemed a shock. But, it seems somewhat of an extreme to postulate static expectations. Adjustment policies consisted of export promotion (increases in export market shares), increased borrowing (relative to past trends), import substitution (decreases in income elasticity of import demand compared with the period 1963-73), and deflation (reduction in income growth relative to the 1963-73 trend).

Mitra quantifies shocks through an open economy macroeconomic model of each country studied (50,51). The model was estimated using annual data for 1963-81 and introduced a dummy variable in the slopes and intercepts of each of the four structural equations of the model to distinguish the shock and adjustment period 1974-81 (dummy taking the value 1) from the pre-shock period of 1963-73 (dummy taking the value zero). The predictions from the model for the period 1974-81 are compared with the predictions for the same period obtained by assuming that the coefficients of the slope and intercept dummy were zero, that assuming that the pre-shock structure prevailed in the post-shock period and that there was no shock to the exogenous variables. The difference in the two predictions for each of the relevant macroeconomic variables is the impact of the shock. It is then decomposed through straightforward accounting into price and quantity changes.

The exogenous variables were (1) the trend value of the export and trade-weighted average of GDP in the three most important trading partners of a country, (2) the index of the price of its exports relative to the price of manufactured exports of OECD countries (that is a deflator of nominal export earnings used to obtain its purchasing power), (3) the index of the price of its imports relative to the same numeraire, (4) real investment, and (5) real net factor income from abroad. Absence of shock is assumed to imply that the first variable continued along its 1961-73 trend in the first period, the second and third stayed at their 1971-73 values, share of real investment in real GNP stayed at its 1971-73 value, and real factor income in the first shock period equaled its actual value. Thus, Mitra's counterfactual is a combination of Balassa's static expectations and extrapolation of past trends with respect to some variables and perfect foresight in respect to real factor incomes.

Mitra groups countries into five groups according to their modes of adjustment. Group 1 (Chile, Costa Rica, the Philippines, Singapore, South Korea, and Taiwan) adjusted principally through export expansion and public resource mobilization (that is, policies affecting the response of public consumption and revenues to income). Group 2 (Argentina, Brazil, Guatemala, Honduras, India, Kenya, Malawi, Mali, Thailand, Turkey, and Uruguay) relied on either export expansion or public resource mobilization. Group 3 (Jamaica, Portugal, and Yugoslavia) adjusted through import substitution and negative public resource mobilization. Group 4 (El Salvador, Mexico, Morocco, Pakistan, and Spain) resorted to financing without domestic adjustment. The last group (Benin, Bolivia, Colombia, Indonesia, the Ivory Coast, Malaysia, Niger, Nigeria, and Tunisia) was lucky enough to have experienced favorable shocks. The underlined countries in each group are semi-industrial, and their adjustment to shock is analyzed in Mitra (51).

The magnitude of the shocks and the adjustments as per the Balassa and Mitra methodologies are shown in tables 4 and 5. I very much agree with Balassa's a priori arguments that outward-oriented economies are better placed to adjust to external shock even though the very fact that they are integrated to a greater extent with the rest-of-the-world than the inward-oriented ones tend to magnify their external shocks. For instance, in the inward-oriented economies, the import control regimes usually would have succeeded in eliminating all imports other than those related to the operation and expansion of productive capacity (mostly industrial and infrastructural capacity), and in establishing high cost, uneconomically sized plants producing domestic substitutes. It is also likely that their steps toward attenuating some of the deleterious effects of excessive import substitution through export promotion are also likely to involve direct subsidization of

Table 4--External shocks and policy repsonses to those shocks for groups of developing economies

Item	Terms of trade effects	Export volume effects	External shock total	Interest rate effect	Together	Additional net external financing	Export promotion	Import substitution	Effects of lower GDP growth
	---------Percent of GNP--------					---------Percent of external shock----------			
Outward-oriented:									
NIC's--									
1974-78	6.5	2.9	9.4	- -	9.4	-50.1	54.0	71.7	24.4
1979-83	8.9	6.1	15.0	1.8	16.8	-24.7	29.3	29.1	66.3
LDC's--									
1974-78	5.9	1.2	7.0	- -	7.0	57.0	29.8	11.5	1.7
1979-83	7.0	1.4	8.4	1.3	9.7	53.3	27.5	1.6	17.6
NIC's and LDC's--									
1974-78	6.3	2.4	8.8	- -	8.8	-26.5	48.7	58.5	19.4
1979-83	8.4	4.9	13.3	1.7	15.0	-11.5	29.0	24.5	58.1
Inward-oriented:									
NIC's--									
1974-78	3.6	.8	4.5	- -	4.5	58.5	-13.6	41.2	13.9
1979-83	2.1	.4	2.5	2.0	4.6	5.1	22.8	15.4	56.7
LDC's--									
1974-78	3.4	1.0	4.4	- -	4.4	150.6	17.6	-36.5	3.5
1979-83	4.5	.9	5.4	.7	6.1	96.7	-9.0	-.6	12.9
NIC's and LDC's--									
1974-78	3.6	.9	4.5	- -	4.5	89.0	-14.9	15.4	10.5
1979-83	2.8	.6	3.4	1.6	5.0	37.6	11.5	9.8	41.2

- - = Not applicable.
Source: Private communication from B. Balassa.

nontraditional exports, while continuing to penalize their traditional exports. This means that when an external shock hits the economy very few imports can be cut without jeopardizing growth and further import substitution or export promotion (the same lines as before the shock) can be achieved only by increasing costs. Thus, inward orientation can substanitially increase the cost of adjustment.

It is not clear, however, whether the increased cost of inward orientation can be inferred from the a posteriori results of table 4. After all is said and done, these portray the effects on two sides of an accounting equation. On one side, external shocks affect export earnings, import payments, and interest on foreign debt. On the other side, adjustment involves financing (without domestic adjustment), domestic adjustments that relate to export supplies, import demands, and those that relate to components of GDP. The fact that components relating to adjustment differed between countries does not, in and of itself, indicate whether all modes of adjustment were feasible for all countries, and even more important is, whether a particular mode was more or less costly in some well-defined sense than the other.

Table 5--Balance-of-payments effects of external shocks and modes of adjustment as a percentage of local currency, gross national product

Item	Group I		Group II		Group III		Group IV		Group V	
	1974-78	1974-81	1974-78	1974-81	1974-78	1974-81	1974-78	1974-81	1974-78	1974-81
					Percent					
A. External shocks										
1. International price effects--										
a. Export price:										
(i) Direct	-1.97	-2.87	-.63	-.45	-3.86	-3.24	-3.26	-2.31	-7.59	-9.26
(ii) Indirect	-2.38	-3.05	-.37	-.37	-2.87	-2.34	-1.75	-1.06	-2.93	-3.57
Difference (=(i)-(ii))	.41	.18	-.27	-.8	-.99	.89	-1.41	-1.25	-4.66	-5.69
b. Import Price										
(i) Direct	6.08	8.06	3.16	3.71	4.55	4.98	2.03	1.28	2.03	2.41
(ii) Indirect	4.81	5.80	1.44	1.72	3.20	3.47	1.03	.53	.90	1.24
Difference (=(i)-(ii))	1.27	2.25	1.72	2.00	1.34	1.51	1.00	.75	1.13	1.17
Sum (1a + 1b)	1.68	2.43	1.45	1.91	.35	.61	-.41	-.50	-3.53	-4.52
2. Recession-induced Effect--										
a. Export volume	1.97	2.04	.60	.69	1.18	1.30	1.22	1.46	.73	1.27
b. Import saving	1.27	1.28	.30	.39	.84	0.91	.65	0.81	.08	.33
Difference (=(i)-(ii))	.70	.76	.30	.34	.39	0.57	.66	0.65	.65	.93
3. Net interest rate effect:										
a. Payments Effect--										
(1) Medium and long term	-.11	.68	-.9	.18	.05	0.72	.06	.45	.10	.75
(11) Short term	-.1	.87	-.1	.16	.00	0.40	-.03	.22	-.01	.15
Sum (=(1) + (11)	.10	1.54	-.10	.34	.04	1.12	.03	.68	.09	.90
b. Receipts Effect	.1	.76	-.1	.9	-.10	-0.15	.00	.06	.00	.28
Difference (=3a - 3b)	.10	.78	-.9	-.25	-.14	1.27	.04	.62	.09	.63
4. Total Shock (= 1 + 2 + 3)	2.48	3.98	1.66	2.47	.83	2.27	.20	.77	-2.79	-2.96
B. Modes of adjustment										
1. Trade Adjustment										
a. Exort expansion										
(1) Direct effect	12.79	17.05	.75	1.66	-7.60	-7.31	-.63	.02	-.02	.25
(11) Import augmenting effects	9.09	11.60	.18	.55	-5.41	-5.23	.32	-.13	-.91	.58
Difference (=(1) - (11))	3.70	5.45	.57	1.11	-2.19	-2.08	.31	.15	.89	.83
b. Import substitution										
(i) Direct effect	.97	-4.20	.87	.85	4.68	4.43	-3.32	-3.28	-3.88	-5.04
(ii) Indirect effect	1.45	-2.59	.36	.38	3.38	3.13	-1.55	-1.28	-.17	-.36
Difference (=(1) - (11))	-.48	-1.61	.50	.48	1.31	1.30	-1.77	-2.00	-3.71	-4.68
Sum (= 1a + 1b)	3.22	3.84	1.07	1.59	-.88	-.78	-1.46	-1.86	-2.82	-3.85
2. Resource mobilization										
a. Private	1.08	.54	-.61	-.44	-1.53	-.96	.72	.65	.98	1.27
b. Public										
(1) Public consump. restraint	-.09	.19	-.69	-.88	-2.93	-4.04	.61	-.87	.25	.16
(11) Tax Incensification	.49	.49	-.10	-.12	.28	.39	-.25	-.24	-.86	-1.14
Sum (=(1) + (11))	.40	.68	-.79	-1.00	-2.65	-3.64	-.86	-1.11	-.61	-.98
Sum (= 2a + 2b)	1.48	1.22	-1.39	-1.44	-4.18	-4.61	-.14	-.46	-1.37	.29
3. Investment Slowdown	-1.13	-1.91	-.46	-.69	2.48	2.78	-1.60	-.84	-1.31	-1.74
4. Net Additional Ext. Financing	-1.09	.83	2.45	3.01	3.41	4.88	3.39	3.93	.97	2.34
5. Total (= 1 + 2 + 3 + 4)	2.48	3.98	1.66	2.47	.83	2.27	.20	.77	-2.79	-2.96

Source: (50,Table 4.1).

Balassa was careful to define his indicator of success of adjustment as GDP growth rate, and he relates the adjustment path as revealed by the magnitude of different components in table 3 to growth performance. Yet, without a well specified model of the relationship between the set of feasible paths of adjustment and the development strategy adapted by a country, it is hard to assess his argument that in response to the initial shock of 1973 the outward-oriented economies did not increase their external debt but relied on output increasing polices of export promotion and import substitution after initially deflating their economies. Table 4 reveals the dominant response of outward-oriented LDC's was external financing and import substitution played a minor role. In the case of outward-oriented NIC's, deflation was the dominant mode of adjustment in 1979-83. Even when the outward-oriented NIC's and LDC's are put together, the dominant response in 1979-83 is not output-raising policies but the output-reducing policies of lower GDP growth.

The analysis of Mitra is, based on a macroeconomic structural model that incorporates a behavioral response to the evolution of exogenous variables (and with the break in the structure after 1973) as well as to shocks in their evolution. The structural system is driven only by gross national income (corrected both for capital gains and losses on net debt as well as terms-of-trade changes). This is admittedly a simple framework for analyzing adjustments. He concludes that in many semi-industrial countries attempts to adjust to exogenous external shocks were compromised by domestic public sector profligacy and the use of exchange rate policy to counter inflation generated by such profligacy was counter productive. These are of important policy significance, if they are confirmed by a more elaborate analysis including more countries.

Some Recent Theoretical Models of Trade and Development

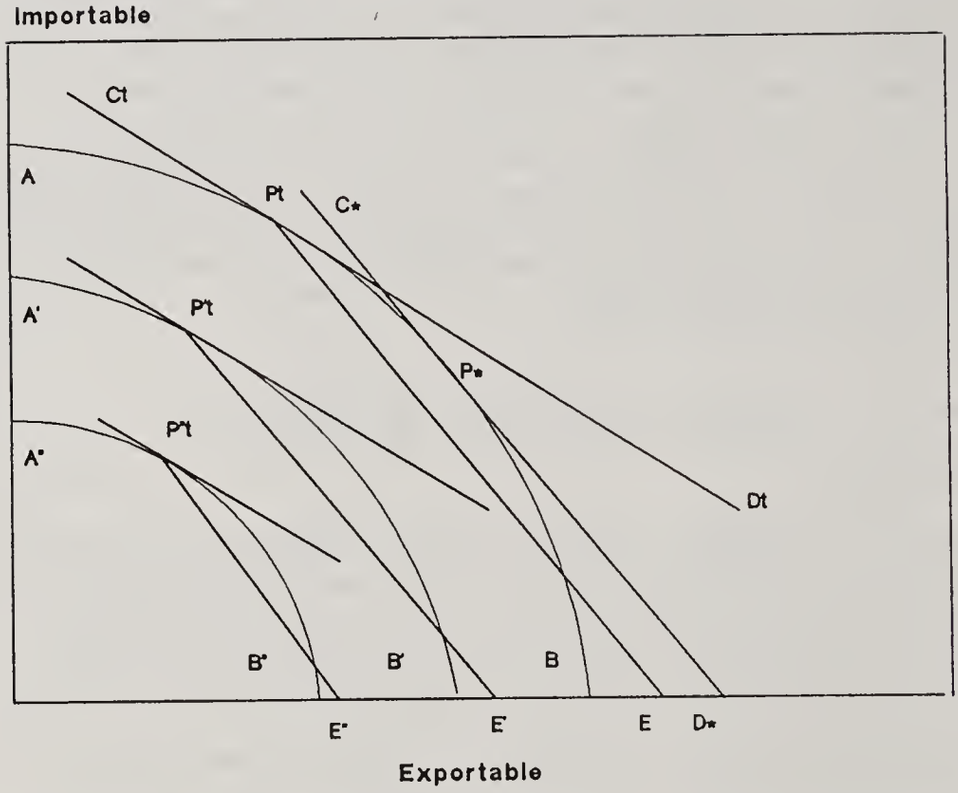
Rent-Seeking and DUP Activities

It was noted that policy instruments used to implement an inward-oriented strategy of development are likely to trigger rent-seeking activities. Since Anne Krueger's (39) classic article on the diversion of resources toward rent seeking, an analytical framework for integrating such activities, which have been characterized by Bhagwati (9) as DUP (directly unproductive profit-seeking activities), into traditional models of trade theory has emerged. With this framework, a number of diverse theoretical results and empirical observations (such as immiserizing growth (7), negative value added at world prices of heavily protected domestic activities in developing countries, negative shadow prices for factors in project evaluation, the impact of rent and revenue seeking on domestic welfare and, on the ranking alternative policy interventions for achieving noneconomic objectives) can all be seen as arising from basically the same underlying structural feature of a distorted economy. Thus, given an existing distortion (such as an import tariff in a small open economy or some other nonoptimal tax), any addition to factor supplies through accumulation or diversion of factors from their existing use toward a project (or for rent seeking, revenue seeking and lobbying) can reduce welfare. This can be seen in the case of immerizing growth, by accentuating the effects of that distortion or improve welfare and, in the case of negative shadow price for a factor, by attenuating them. It also turns out that if the diversion of resources to rent seeking are of the same value in equilibrium as the rents sought, then a policy, such as an import tariff, which has a higher welfare cost in the absence of revenue seeking than a production tax for achieving a noneconomic objective of raising the output of a sector (beyond the level achieved in a laissez-faire equilibrium), can become superior to it with revenue seeking present (14).

One implication of the presence of rent seeking was already mentioned. The gains to those policies that eliminate distortion that triggered the rent seeking could be substantially greater than the cost estimates of the same distortion in the absence of rent seeking. If we also include the resources devoted to lobbying for the adoption of the distortionary policy in the cost of distortion, it can be substantial. This is easily illustrated by using the traditional approach to the cost of protection. In figure 1, AB represents the production possibility (PP) curve of a small open economy if all its resources are devoted to production activities. C^*D^* represents an iso-value line at world prices. The economy will operate at P^* under free trade. If a tariff is imposed by the government without anyone lobbying for its imposition or for the diversion of revenues it generates once imposed, the iso-value line becomes C^tD^t and the economy will produce at Pt and the production cost of protection is measured by the difference ED^* between the value at world prices of P^* as compared with P^t. Now, first introduce lobbying for the tariff rather than it being imposed autonomously. The resources diverted to the lobbying activity (which remains diverted because a tariff once imposed may not remain in place unless the lobby continues to plead for it) shrinks the PP curve to A'B' and the production point shifts to P'^t. If there is resource using struggle for the disposition of the revenue

Figure 1

Cost of protection and DUP activities



generated by the tariff, the PP curve shrinks further to A"B" and the production point moves to $P^{"t}$. The total production cost of protection then is E"D*, consisting of the sum of cost of revenue seeking E"E', the cost of lobbying for the tariff E'E, and the traditional cost ED*.

If rent seeking had the effect of reducing the cost of the distortion that triggered it as in some of the examples above, the gains from elimination of the distortion may be less. Indeed, some forms of corruption and extra legal transactions in developing countries and some centrally planned economies may even improve the efficiency of an otherwise extremely inefficient bureaucratic allocation system. In such cases, the economic gains toward a less bureaucratic allocation system may be less than what might seem on the surface.

North-South Models

The so called north-south models build on assumed structural difference between the developed north and developing south. In the Findlay version, each region is specialized in producing its export good (28). The north produces a single homogeneous manufactured goods under a constant returns to scale neoclassical technology with capital and labor as inputs, saves a fixed proportion of its output, and fully employs its exponentially growing labor force in a competitive market for goods as factors. The part of the output that is not saved or invested is spent either on domestic manufacturers or on imports of primary products from the south. South's technology for the production of exports is again neoclassical with capital and labor as inputs, except that labor supply to the export sector is infinitely elastic at a fixed product wage. Southern workers consume all their wages, and capitalists save part of their profits. Consumption expenditures of workers and capitalists are divided between spending on home produced primary products and imported manufacturers, depending upon relative prices.

A unique steady-state equilibrium in which north and south grow at a rate equal to the growth rate of the effective supply of labor in the north is shown to exist. Also, convergence to this steady state from arbitrary initial conditions is established. The comparative dynamics (that is, impact on the steady-state equilibrium) of increases in the northern propensity to save and improvements in its technology are simply that its per

capita income increases and its terms of trade improve, while the south loses on both counts. As Findlay himself admits, the assumptions of the model such as the absence of capital mobility in response to differing profit rates between north and south, production specialization, and unlimited labor supply at a fixed real wage in the south are very restrictive. I would add the exogenously specified savings propensities and population growth rates to his list. But the fundamental problem is that while these rigidities and fixities may make some sense in the short or even medium run, to keep them fixed forever and take the comparative dynamics of the long-run steady states emerging from them as stylized development stories is seriously misleading. Besides the intertemporal gains or losses along the transitional path toward the new steady state are ignored in focusing exclusively on the steady state. Such gains or losses may reverse the conclusions derived from steady-state comparisons.

Another north-south model that builds in even more rigidities than Findlay's is attributed to Kaldor (71). In this model, the north is specialized in producing an industrial output, using capital and labor in fixed proportions to output. Real wages are exogenous and fixed, and any surplus of output over sales to the southern and northern consumption is invested. The south is specialized in producing an agricultural good, using land, labor, and capital. Capital-labor ratio is fixed. In the short run and intermediate run, diminishing returns arising from the fixity of land are assumed absent so that the capital-output ratio in agriculture is constant. In the long run, substitution (at a diminishing marginal rate) between land and labor is allowed. Southern real wage is also fixed (in terms of the agricultural good). Wages and rents are consumed in agricultural goods, while all profits are invested. Thus, the agricultural surplus of the south is exchanged for northern capital goods. Northern workers do not save but split their consumption between the industrial good and agricultural good, depending on relative prices.

It is shown that in the short run, with given stocks of capital in the north and south, the two regions do not grow at the same rate, the two growth rates are determined by the equilibrium terms of trade, with more favorable terms of trade for the south leading to its faster growth. In the medium run, the equilibrium capital stocks as well as the terms of trade are jointly determined. The two capital stocks grow at the same equilibrium rate depending on capital productivity in the two regions and on their share of consumption in output. In the long run, the growth rate of the system is the same as that of the effective stock of agricultural land. Another feature of this model is that adjustments to an exogenous fall in southern productivity may involve overshooting in the sense that the terms of trade rise above their medium-run equilibrium value and gradually fall toward it. Further, the path toward longrun equilibrium value of the ratio of capital stocks in the two regions and the land to capital ratio in the south may involve cyclical behavior. The overshooting and cyclical adjustment are viewed by Vines as formally establishing Kaldor's indictment of the price mechanism as a perverse and slow acting mechanism that creates unnecessary cycles in world industrial activity. As in Findlay's model, the extreme assumptions of this model appear to be ill suited to an analysis of the long-run development process (71).

Vines and Kanbur (72) use a simpler version of the Vines model in which southern output of agriculture is price-inelastic and northern macroeconomy is Keynesian to argue that benefits to the stabilization of agricultural prices through a buffer stock operation can yield substantial benefits to the north if northern real wages are sticky. Buffer stock operation avoids a deflationary policy that would otherwise be necessary to contain inflation whenever agricultural prices rise because of harvest failure in the south. By ignoring private stock operations and the role of price expectations, speculation, and by exaggerating the inflexibilities in the system (besides real wage inflexibilities) through the assumption of fixed propensities, the model is likely to exaggerate the gains that accrue from publicly funded buffer stocks.

Recent Models of International Trade

Turning now to developments in the theory of international trade, only two will be briefly noted. One is the application of Neo-Ricardian time-phased models and neo-Marxian analysis (under the broad theme of unequal exchange) of international trade. Evans offers a perceptive critique of these models (28). The second is the intellectual arbitrage between industrial organization theory and international trade theory by Krugman and Helpman (38,43,44,45) and others. Stewart has attempted to derive some implications for the south from this theory (68).

The time-phased Ricardian models are viewed by their builders as repairing what they consider two damaging features of traditional models of trade and growth, namely, their treatment of capital as a homogeneous aggregate and their ignoring the time lags involved in production. By adopting Von-Neumann's formulation of production in terms of activities that transform a vector of inputs into a vector of outputs one period later, they address both these concerns.[5]

They focus only on the steady state (the state of balanced growth) of the system. The two conclusions of this theory are worth nothing: first, for a small open economy the steady state associated with autarky (or with restrictions on international trade) may yield higher consumption every period than that associated with free trade; and second, the commodity pattern of trade can change along the approach to the steady state. Indeed it can be reversed; a commodity exported at one point can be imported at another. It should be noted that neither conclusion depends on the Ricardian time-phased structure of the model: a standard two-commodity, two-factor, Heckscher-Ohlin-Samuelson model in its dynamic version in which one of the commodities is an investment good and with no-time lags in production can be used to derive them. The fact that trade restrictions lead to higher consumption than free trade in a steady state does not imply that restricting trade is intertemporally optimal. Indeed, the contrary is true for a small open economy under free trade (17,59).

In the literature on unequal exchange (27), the north is the center and the south is the periphery. The process of international exchange and investment is assumed to equalize the rate of return to capital in the center and the periphery. The return to labor is not equalized, and this inequality is alleged to grow. Since the exchange between the center and the periphery is voluntary, it is not clear that unequal wages between regions should be viewed as indicating that the commodity exchange itself is unequal. However, if one is prepared to define suitably the content of "socially necessary labor" in commodities being exchanged (using a model that will enable one to do so unambiguously), one can arrive at a precise definition of "unequal exchange" as exchange of commodities of unequal content of socially necessary labor. Roemer follows this route (55). Few would be bold enough to infer policy relevant conclusions from the existence of unequal exchange in the sense of Roemer.

The intellectual arbitrage between industrial organization theory and international trade theory came about initially as an attempt to explain (better than conventional theory) certain stylized facts of international trade. These facts were: first, even at the most

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[5]The issue of heterogeneity of capital attracted some extensive attention in the so called Cambridge (MA) versus Cambridge (England) controversies in capital theory. A few of the uninformed have somehow come to the conclusion that neoclassical economic theory stands or falls on the validity of the homogeneity of capital. Malinvaud in his seminal paper on capital accumulation had, among other things, given a perfectly rigorous meaning for the concept of marginal productivity of capital in a model in which capital goods were heterogeneous (48). This paper apparently was not read by many of the Neo-Ricardians or Sraffians. Hahn lucidly exposes the misunderstanding and confusion that surround the Neo-Ricardian discussion of the neoclassical economics (33).

disaggregated level, the trade among industrialized countries appear to consist largely of intraindustry trade, each country exporting as well as importing commodities that would be classified as falling within the same industrial category; second, significant economies of scale in production appeared to characterize the technology of some of these industries; and third, such industries in many countries appeared to be highly concentrated, often with very few firms. Recent theories explain the above stylized facts by drawing on the model of monopolistic competition in an industry producing a set of differentiated products under increasing returns to scale and setting it in the context of international trade. An interesting result is that in contrast to traditional theories, gainful exchanges will arise even between two economies that are identical in every respect. Given economies of scale, each country will produce a different set of (differentiated) products of the same industry, but consumers in each will be able to buy products produced in both. This raises consumer welfare in both countries, compared with what could be achieved by each country under autarky. A consequence of the oligopolistic equilibrium that characterizes international exchange in some of the models is that it would be in the interest of each country to attempt to capture more of the oligopolistic rents that arise from the divergence between equilibrium prices and marginal costs. This brings in a role for active strategic trade interventions that is not present in traditional theories.

The implications of the above for the developing countries are far from obvious. First, the case for strategic intervention and the type of intervention are very sensitive to the specification of the model and the concept of the equilibrium used. Second, the arguments for trade interventions that the new theory allows cannot to be taken as analytical support for the particular interventions that developing countries have imposed in totally different contexts. Starting from the premise that few developing countries will be able to establish a viable industry producing differentiated products under economies of scale, Stewart has suggested that the south as a group could, however, do so if each country specialized in one or at most a few products and traded them with each other. This argument for the south-south trade, however, does not follow the above theory, except in that there is a common assumption that the greater the variety of products consumed, the greater is consumer welfare. Since the argument also assumes protection against imported products of the same industry from the north, it really involves diverting northern trade and creating trade among southern countries. There is no presumption that this is necessarily welfare improving for the south.

Trade among the developed industrialized economies with similar tastes, technologies, and factor endowments is largely intra-industry, two-way trade (and this is the starting point of newer theories of trade); however significant intra-industry trade takes place among developing countries as well. Havrylyshyn and Civan find in a regression analysis that per capita income and the diversity of manufactured goods exports, besides membership in a successful trading group (such as the EC), explain a significant proportion of the variation in intra-industry trade among countries (34). The stage of development matters. While 60-80 percent of all trade in industrialized countries is intra-industry, the percentage is between 40-50 percent in the newly industrialized countries and is only between 10-20 percent in other developing countries. The authors argue that this link with stage of development of intra-industry trade in differentiated products implies that as development proceeds the penetration of developing countries into the developed country markets will be diffused over a number of products. As such, such penetration may appear less threatening and invoke less of a protectionist response from the developed countries. This is not entirely convincing. After all the differentiated products presumably come from the same set of industries and lobbying for protection is likely to be industry based rather than product based. There is no reason to believe that such lobbying will be blunted.

A few words about trends in south-south trade are in order in concluding this section. It is sometimes suggested by Stewart (68) that the patterns of financial, transport, and marketing arrangements developed during the colonial era have precluded developing

countries from changing their colonial trade patterns to trading among themselves to greater mutual benefit. This argument is not valid for all developing countries, if it is at all valid for any. For example, India was able to change, fairly soon after its independence, the geographical concentration of its exports from the United Kingdom to other developed countries (such as the United States and USSR), although not as much to other developing countries. Havrylyshyn and Wolf show that the share of nonfuel trade among developing countries did not change between 1963 and 1977 (35). However, this constant share is the sum of a falling share of manufacturers and a rising share of primary products. Furthermore, they did not find any bias against trade among developing countries other then the effect of their own trade restrictions. Exports of manufacturers from developing countries to other developing countries are found to be more capital-intensive than exports to developed countries, a pattern consistent with multicountry generalizations of Heckscher-Ohlin theory. However, the pattern may also have been influenced by trade restrictions in developing countries (40). It is not clear, however, whether promoting south-south trade through distortionary restrictive trading arrangements will mean that gains from trade creation will outweigh the losses from trade diversion and distortions.

International Factor Movements

The welfare implications of international factor mobility have been analyzed extensively by trade theorists in the past several years. The so called brain-drain from developing countries, foreign investment in such countries and the use of immigrant labor in declining industries in developed countries, as a way of reducing labor costs in an attempt to remain viable in the face of competition from other developing countries have all been analyzed. Models used in the analysis have been varied, including the traditional Heckscher-Ohlin model, the specific factors model, and models incorporating increasing returns and monopolistic competition. Even lobbying activities have been incorporated in the analysis. First best and second best policies towards factor movements have also received attention.

In the standard Heckscher-Ohlin-Samuelson (H-O-S) two-factor, two-commodity small open economy model, under conditiona of free trade if foreign investors of imported capital (or immigrant laborers) are paid their marginal value product in the importing country and these returns are repatriated, such factor imports do not change consumer welfare as long as the economy remains incompletely specialized before and after the import of capital (labor). Welfare increases if the economy becomes specialized in the capital (labor) intensive good after capital (labor) imports from an initial position of incomplete specialization (or specialization in the labor (capital) intensive good). In such a situation, the additional capital (labor) import at the margin reduces the economies marginal product, thereby, reducing its cost in terms of payments to intramarginal units of foreign capital (labor).

Brecher and Diaz-Alejandro (20) were the first to show that the above favorable welfare consequences of inflow of foreign factors need not hold if the economy is not following its optimal free trade policy. Indeed, given an existing import tariff, if importables are capital (labor) intensive, even if the economy is not specialized before and after foreign capital (labor) inflow, there is a welfare loss associated with factor imports. To the extent developing countries protect their capital-intensive manufactures and such protection induces "tariff-jumping" foreign investment, the Brecher and Diaz-Alejandro result points to additional welfare loss (over and above the primary loss associated with the protective tariff in the absence of foreign investment) that inward-oriented policies generate. Bhagwati and Srinivasan have argued that outward-oriented policies, on the other hand, are likely to attract welfare, improving foreign investment that takes advantage of relative cheapness of a country's more abundant factor (15).

A number of subsequent studies have examined the welfare of consequences for the home economy of alternate trade policies (first best and second best) in the presence of

foreign-owned factors of production (11,19,63). Other authors consider the choice between emigration of home labor (investment abroad of home capital) and attracting foreign investment (attracting foreign workers). They extend and generalize a result originally due to Ramaswami (53,54). He considered a model in which a single homogeneous commodity was produced under constant returns to scale in two countries using capital and labor as inputs. Although there is no incentive for commodity trade in this model, incentives for factor movements arise because of different factor endowment ratios in the two countries. He showed that for the capital poor country that can optimally tax earnings of foreign capital or the income of its nationals working abroad, the optimal policy is to attract and tax foreign capital rather than let home workers emigrate and tax their earnings. This result or variants of it in more general contexts are in studies by Bhagwati and Srinivasan (17), Calvo and Wellisz (23), Jones, Coelho and Easton (38), Wong (74), Saavedra-Rivano and Wooton (57). Except for Saavedra-Rivano and Wooton who worked with a dynamic north-south model of the Findlay (28) type, the analyses of the above authors are static. Buiter (21), on the other hand, analyzes the pattern of capital formation, balance-of-payments behavior, and welfare in a dynamic, two-country, over-lapping generation, general equilibrium model in which countries differ only in their pure rates of time preference and there is perfect international capital mobility. With a positive rate of natural growth, the low-time preference country runs current account surplus (exports capital) in the steady state though not necessarily outside it. The ranking of steady-state utility levels under autarky and free trade and capital mobility is ambiguous. Galor (29) independently of Buiter uses essentially the same model to analyze the implications of international migration. He finds that there is unilateral migration from the high- (low) time preference to the low- (high) time preference country if the autarkic steady-state equilibrium in both countries is characterized by under (over) investment relative to the Golden Rule. Bilateral migration occurs if the two countries are located on the opposite sides of the Golden Rule. In contrast with the other analyses discussed above, Galor's model of unilateral migration impoverishes the nonmigrants in the immigration country, while nonmigrants in the emigration country are no worse off.

Leontief (45) suggested that an unilateral transfer of income from one country to another in a two-country, two-commodity, pure-exchange world may impoverish the recipient, while enriching the donor. Samuelson (58) showed that such a possibility cannot arise unless the equilibrium is Walrasian stable. This so called transfer paradox has recently received independent attention from several authors. By introducing a third country or by introducing domestic distortions, one can resurrect the transfer paradox even in a stable equilibrium. The possibility arises that both the donor and the recipient are enriched by the transfer. However, some researchers may jump to the conclusion that the transfer paradox has the implication that foreign aid can impoverish developing countries. Such a conclusion would be hasty, in part, because the transfer-induced change in equilibrium terms of trade on which the paradox depends is unlikely since aid is quantitatively very small relative to the value of global trade and, in part, because the above analyses ignores policy responses (such as removal of distortion) that can negate the paradoxical outcome.

One particular institutional arrangement under which international investments and technology transfer have taken place is the multinational corporation, which has received theoretical and empirical attention (36). For brevity, this literature and that on direct-foreign investment (49) are not discussed here.

In concluding this section, recent experience with international migration must be mentioned. The boom in the oil rich west Asian countries after the first oil shock induced a substantial emigration of labor from south and east Asia, as well as the Arab world, to these countries. At their peak, the remittance to their families by these emigrant workers constituted a half or more of the foreign exchange earnings of many of the countries of origin. With the decline in oil prices and the contraction of investment in oil-exporting countries, growth in the use of immigrant labor in these countries is unlikely in the near

future and, in fact, the net flow will probably turn negative. The investment of remittances by the families of emigrants in housing, small enterprises, and other activities has transformed some parts of south Asia with an unusual concentration of such emigrants. The returning emigrants brought with them, in addition to their savings, the skills, knowledge, and an altered outlook acquired during their sojourn abroad. (70,75).

Conclusion

The development of sharper theoretical and econometric tools and the accumulation of a large and growing body of economic data relating to developing countries have enabled a number of analysis to compare outward- and inward-oriented strategies of development. Most analysts, though not all, have concluded that countries that followed an outward-oriented strategy not only did better by most indicators of development but also better weathered the shocks to the world economy. Recent policy changes in the two giants of the developing world (India and China) toward economic liberalization suggest that the lessons of three decades of development have been learned. Some pessimists argue that if the two giants and the rest of the developing countries were to adopt an outward orientation, it will exacerbate the rising tide of protectionism in the industrialized world besides imposing terms-of-trade losses on the developing countries. However, given the fact that manufactured exports of the developing world still accounts for less than 5 percent of the apparent consumption of such commodities in the developed world, and the recovery in the industrialized world continues, such fears seem exaggerated. This is not to say, however, that problems cannot arise with regard to particular commodities or countries.

REFERENCES

(1) Adelman, I., and S. Robinson. Income Distribution Policy in Developing Countries: A Case Study of Korea, London: Oxford University Press, 1978.

(2) Balassa, B. Development Strategies in Semi-Industrial Economies, Baltimore, MD: Johns Hopkins University Press, 1982.

(3) _____. Developing Country Debt: Policies and Prospects, Report No. DRD 149. Development Research Center, World Bank, Washington DC 1985.

(4) _____. Change and Challenge in the World Economy. London: Macmillan, Part II, 1986.

(5) _____. "Policy Responses to Exogenous Shocks in Developing Countries," American Economic Review, Papers and Proceedings. 1986, pp. 75-78.

(6) Bell, C.L.G., and T.N. Srinivasan. "On the Uses and Abuses of Economywide Models in Development Policy Analysis," Economic Structure and Performance. Eds. M. Syrquin, L. Taylor and L. Westphal. New York: Academic Press, Ch. 22, 1984, pp. 451-476.

(7) Bhagwati, J.N. "Immiserizing Growth: A Geometrical Note," Review of Economic Studies. Vol. 25, 1958, pp. 201-205.

(8) _____. Foreign Trade Regimes and Economic Development: Anatomy and Consequences of Exchange Control Regimes. Cambridge: Ballinger Press, 1978.

(9) _____. "Lobbying and Welfare," Journal of Public Economics, Vol. 14, Dec. 1980, pp. 355-363.

(10) _____. "Rethinking Trade Strategy" Development Strategies Reconsidered. Eds J.P. Lewis and V. Kallab. Overseas Development Council, Washington, DC 1986, pp. 91-104.

(11) _____ and R. Brecher. "Foreign Ownership and the Theory of Trade and Welfare," Journal of Political Economy. Vol. 89, 1981, pp. 497-511.

(12) _____ and _____ and T. Hatta. "The Generalized Theory of Transfers and Welfare: Bilateral Transfers in a Multilateral World," American Economic Review. Vol. 83, 1983, pp. 606-618.

(13) _____ and _____ and _____. "The Generalized Theory of Transfers and Welfare: Exogeneous (Policy-Imposed) and Endogenous (Transfer Induced) Distortions," Quarterly Journal of Economics. Vol. 13, 1985 pp.353-364.

(14) _____ and _____ and T.N. Srinivasan. "DUP Activities and Economic Theory," Neo-Classical Political Economy. Ed. D. Colander, Cambridge, England: Ballinger Publishing Co., Ch. 1, 1984, pp. 17-32.

(15) _____ and T.N. Srinivasan. "Trade Policy and Development," International Economic Policy: Theory and Evidence, Eds. R. Dornbusch and J.A. Frenkel. Baltimore, MD Johns Hopkins Press, 1979, pp. 1-35.

(16) _____ and _____. "Trade and Welfare in a Steady State," Flexible Exchange Rates and Balance of Payments. Eds. J.S. Chipman and C.P. Kindleburger, Amsterdam: North-Holland Publishing, 1980, pp. 341-353.

(17) _____ and _____. "On The Choice Between Capital and Labour Mobility," Journal of International Economics. Vol. 14, 1983, pp. 209-222.

(18) Blitzer, C.R., P.B. Clark, and L. Taylor (eds.), Economy-Wide Models and Development Planning. London, Oxford University Press, 1975.

(19) Brecher, R.A. "Second Best Policy for International Trade and Investment," Journal of International Economics. Vol. 14, 1983, pp. 313-320.

(20) _____ and C. Diaz-Alejandro. "Tariffs, Foreign Capital and Immiserizing Growth," Journal of International Economics. Vol. 7, 1977, pp. 317-22.

(21) Buiter, W.H. "Time Preference and International Lending and Borrowing in an Overlapping-Generations Model," Journal of Political Economy. Vol. 89, No. 4, 1981, pp. 769-797.

(22) Cairncross, A.K. "International Trade and Economic Development," Kyklos. XIII, Fasc. Vol. 4, 1960.

(23) Calvo, G., and S. Wellisz. "International Factor Mobility and National Advantage," Journal of International Economics. Vol. 14, 1983, pp. 103-114.

(24) Chenery, H.B., and M. Bruno. "Development Alternatives in an Open Economy," Economic Journal. Vol. 72, 1962, pp. 79-103.

(25) _____ and A. Strout. "Foreign Assistance and Economic Development," American Economic Review. Vol. 56, 1966, pp. 679-733.

(26) Dasgupta, P., S. Marglin, and A.K. Sen. Guidelines for Project Evaluation. New York, United Nations. York, Monthly Review Press, 1972.

(27) Evans, D. "A Critical Assessment of Some Neo-Marxian Trade Theories," Journal of Development Studies. 1984, pp. 202-226.

(28) Findlay, R. "The Terms of Trade and Equilibrium Growth in the World Economy," American Economic Review. Vol. 70, June 1980, pp. 291-299.

(29) Galor, O. "Time Preference and International Labour Migration," Journal of Economic Theory. Vol. 38, No. 1, 1986, pp. 1-20.

(30) GATT International Trade 1984/85. General Agreement on Tariffs and Trade. Geneva, 1985.

(31) Grais, W., J. Demelo, and S. Urata. "A General Equilibrium Estimation of the Reduction of Tariffs and Quantitative Restrictions in Turkey in 1978", General Equilibrium Trade Policy Modeling. T.N. Srinivasan and J. Whalley Cambridge, MA: M I T Press, 1986, pp. 61-88.

(32) Hahn, F. "The Neo-Ricardians," Cambridge Journal of Economics. Vol. 6, 1982, pp. 353-374.

(33) Harris, R. Trade, Industrial Policy, and Canadian Manufacturing. Toronto, Ontario Economic Council, 1983.

(34) Havrylyshyn, O., and E. Civan. "Intra-Industry Trade and Stage of Development" Intra-Industry Trade: Empirical and Methodological Aspects, P.K.M. Tharakan Eds. Amsterdam: North-Holland Publishing, 1983, pp. 111-140.

(35) _____ and M. Wolf. "Recent Trends in Trade Among Developing Countries," European Economic Review, Vol. 21, 1983, pp. 333-362.

(36) Helleiner, G. Intra-Firm Trade and the Developing Countries. London: Macmillan 1981.

(37) Helpman, E. "International Trade in the Presence of Product Differentiation, Economies of Scale and Monopolistic Competition", Journal of International Economics, Vol. 11, 1981, pp. 305-340.

(38) Jones, R.W. , Coelho, I., and S.T. Easton, "The Theory of International Factor Flows: The Basic Model," Journal of International Economics. Vol. 20, 1986, pp. 313-328.

(39) Krueger, A. "The Political Economy of the Rent Seeking Society," American Economic Review. Vol. 64, 1974, pp. 291-303.

(40) _____. Foreign Trade Regimes and Economic Development: Liberalization Attempts and Consequences, Cambridge, Ballinger Publishing Company, 1978.

(41) _____. Alternative Trade Strategies: Synthesis and Conclusions, Chicago IL: Chicago Univ. Press. Vol. 3, 1983.

(42) Krugman, P. "Increasing Returns, Monopolistic Competition and International Trade," Journal of International Economics. Vol. 9, 1979, pp. 469-479.

(43) _____. "A Model of Innovation, Technology Transfer and the World Distribution of Income," Journal of Political Economy. Vol. 70, 1979, pp. 950-959.

(44) _____. "Scale Economies, Product Differentiation and the Pattern of Trade," American Economic Review. Vol. 70, 1980, pp. 950-59.

(45) Leontief, W. "Note on the Pure Theory of Capital Transfers" Explorations in Economics: Notes and Essays Contributed in Honor of F.W. Taussig. New York: McGraw Hill, 1936.

(46) Little, I.M.D., and J. Mirrlees. Project Appraisal and Planning for Developing Countries. London: Heinemann, 1974.

(47) Little, I., T. Scitovsky, and M. Scott. Industry and Trade in Developing Countries: A Comparative Study, London and New York: Oxford Univ. Press, 1970.

(48) Malinvaud, E. "Capital Accumulation and Efficient Allocation of Resources," Econometrica, Vol. 21,: 1953; 233 "Efficient Capital Accumulation: A Corrigendum," Econometrica, Vol. 30, July 1962, p. 570.

(49) Michalopoulos, C. "Private Direct Investment, Finance and Development," Asian Development Review. Vol. 3, 1985, pp. 59-71.

(50) Mitra, P. "A Description of Adjustment to External Shocks: Country Groups," Stagflation Savings and the State of Perspectives on the Global Economy, D. Lal and M. Wolf. Eds. New York: Oxford Univ. Press, 1986 pp. 103-114.

(51) _____. "Adjustment to External Shocks in Selected Semi-Industrial Countries, 1974-81," Adjusting to Shocks: A North-South Perspective. Eds. P. Ferri and G. Ragazzi. Amsterdam: North-Holland Publishing, 1986.

(52) Neary, P. "Theory and Policy of Adjustment in an Open Economy." Discussion Paper 61. London: Center for Economic Policy Research, 1985.

(53) Ramaswami, V.K. "International Factor Movements and National Advantage," Economica. Vol. 35, 1986, pp. 309-310.

(54) _____. "International Factor Movements and National Advantage: Reply," Economica, Vol. 37, 1970.

(55) Roemer, J. "Unequal Exchange, Labour Migration and International Capital Flows: A Theoretical Synthesis," Marxism, Central Planning and The Soviet Economy, Essays in Honor of Alexander Ehrlich. Ed. P. Desai. Cambridge: MIT Press, 1983, pp. 34-60.

(56) Rosen, G. Western Economists and Eastern Societies, Baltimore, MD: Johns Hopkins University Press, 1985 pp. 128-138.

(57) Saavedra-Rivano, N., and I. Wooton. "The Choice Between Labour and Capital Mobility in a Dynamic Model of North-South Trade," Journal of International Economics. Vol. 14, 1983, pp. 251-262.

(58) Samuelson, P. Foundation of Economic Analysis, Cambridge, MA: Harvard University Press, 1947.

(59) _____. "Trade Pattern Reversals in Time-Phased Systems and Intertemporal Efficiency," Journal of International Economics. Vol. 5, 1975, pp. 339-364.

(60) Sandee, J. A Demonstration Planning Model for India. Bombay, India: Asia Publishing House, 1960.

(61) _____, and J. Whalley. "Applied General Equilibrium Models of Taxation and International Trade: An Introduction and a Survey," Journal of Economic Literature. Vol. 22, 1984, pp. 1007-1051.

(62) Srinivasan, T.N. "General Equilibrium Theory, Project Evaluation and Economic Development," The Theory and Experience of Economic Development. Eds. M. Gersovitz, C. Diaz-Alejandro, G. Ranis, and, M. Rosenzweig, London: Allen and Unwin, 1982, pp. 229-251.

(63) _____. "International Factor Movements, Commodity Trade and Commercial Policy in a Specific Factor Model," Journal of International Economics. Vol. 14, 1983, pp. 289-312.

(64) _____. "Development and Strategy: Is the Success of Outward Orientation at an End?" in M.R. Shroff and S. Guhan (eds.), Economic Progress and Welfare: Essays in Honor of I. G Patel, Delhi, Oxford University Press, 1986.

(65) _____ and J. Whalley. General Equilibrium Trade Policy Modeling, Cambridge, MA: MIT Press, 1986.

(66) Steedman, I. (ed.). Fundamental Issues in Trade Theory, London: Macmillan, 1979.

(67) _____. Trade Among Growing Economies, Cambridge, England: Cambridge University Press, 1979.

(68) Stewart, F. "The Direction of International Trade: Gains and Losses for the Third World," A World Divided: The Less Developed Countries in the International Economy. Ed. G.K. Helleiner. Cambridge, England: Cambridge University Press, 1976, pp. 89-110.

(69) _____. "Recent Theories of International Trade Some Implications for the South," Monopolistic Competition and International Trade. Ed. H. Kierzkowski. London: Oxford University Press, 1984, pp. 84-107.

(70) Swamy, G. "Population and International Migration," Staff Working Paper No. 689. Washington, DC, World Bank, 1985.

(71) Vines, D. "North South Growth Model Along Kaldorian Lines," Discussion Paper No. 26. London: Centre for Economic Policy Research, 1985.

(72) _____ and R. Kanbur. "North South Interaction and Commod Control," Journal of Development Economics. Vol. 23 No. 2, 1986, pp. 371-387.

(73) Whalley, J. "The North South Debate and the Terms of Trade: An Applied General Equilibrium Approach," Review of Economics and Statistics. Vol. 66, 1984, pp. 224-234.

(74) Wong, K. "On Choosing Among Trade in Goods and International Capital and Labour Mobility: A Theoretical Analysis," Journal of International Economics. Vol. 14, 1983, pp. 223-250.

(75) World Bank. World Development Report, New York, Oxford University Press, 1982, 1984, 1986.

GOVERNMENT IN THE PROCESS OF TRADE AND DEVELOPMENT

Terry Roe and Mathew Shane [1]

Introduction

Governments play a pervasive role in all aspects of a nation's economy. Policies with regard to the trade sector are particularly important. They determine the degree to which international markets, information, and technology can interact with domestic resources and capacities to generate long-term development patterns.

Countries have taken two distinct approaches. The outward-oriented countries (OOC) have pursued policies that have opened domestic markets to the world economy. The inward-oriented countries (IOC), on the other hand, have pursued policies that tend to isolate the country from the forces of the international marketplace. Although there is a tendency to think that OOC follows laissez-faire policies and the IOC follows interventionist policies, this is not entirely correct. On close examination, both types of countries intervene in their economies. The distinction between these two types of development strategies, therefore, is in the nature of the interventions.

The classical trade argument is that small economies can accelerate the growth process by pursuing an outward-oriented strategy. An outward-oriented strategy enables an economy to specialize and, therefore, attain an equilibrium growth path in excess of what could be achieved using domestic resources alone. Imports serve to increase competition in domestic markets by providing a stimulus for improving product quality and efficiency in the production of import substitutes. Competition in foreign markets provides the same stimulus to producers of exportables goods. Foreign trade in capital and intermediate goods facilitate technical transfers across countries. An open economy also provides economic agents with the opportunity to use world contingent claims markets (insurance, forward, and futures markets) so that unanticipated variations in income streams can be reduced. Another important advantage of openness to world markets is the potential for economic agents to exploit the informational efficiency of world spot and future prices.

Under assumptions that preclude market failure, and given that lump-sum income transfers are possible, the above strategy maximizes exchange, production, and economic efficiencies. According to Buchanan "as long as governmental action is restricted largely, if not entirely, to protection of individual rights, person and property and enforcing voluntarily negotiated private contracts, the market process dominates economic behavior and ensures that any economic rents that appear will be dissipated by the force for competitive entry" (8, p. 14).[2]

The problem is that lump-sum income transfers are seldom feasible and the conditions that give rise to market failure (externalities, public goods, risk, and information asymmetries) are common. Whenever these conditions prevail, collective action by producers, consumers, and the government can give rise to an increase in welfare. Public investments in agricultural research, general and technical education, and infrastructure are typical areas that have high rates of returns (14, p. 63). Technical education and infrastructure have been estimated to account for approximately half of the differences in agricultural labor productivity among a sample of 43 countries (14, p. 151). The provision of information and the support of institutions for risk sharing are other examples of the potential social profitability of government intervention. Economies work imperfectly so that in the process of economic

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[2]Underscored numbers in parentheses are listed in the References at the end of this article.

growth some groups benefit, while others do not. It is often the role of government to redress these imbalances.

Recent studies by Balassa of country adjustments to world economic shocks provide strong empirical evidence that government interventions have been inimical to the growth process in many countries and that while adjustments have occurred in some countries, they have either occurred with considerable lag or because of the inability to finance external debt (5). This experience raises several questions. For instance, why have some countries persisted in their pursuit of interventions that exacerbated adjustments to external shocks or that were wasteful of resources? Are these interventions intended for the overall benefit of their respective economies but, in reality, a sequence of policy mistakes or failures of the planning processes? But, if this were the case, why have countries failed to learn from these mistakes? Or, are interventions the outcome of political pressure exerted by domestic interest groups seeking to achieve outcomes that might favor them but are socially wasteful of resources?

Insights into these questions are important to understanding the consequences of private sector choices on the development process. Since government intervention is pervasive in many countries, our ability to understand private sector choices is restricted because their rules are either conditional on the exogenous variables of government policy or are jointly determined with the policy rules. In the former case, we face problems akin to forecasting the values of exogenous variables; in the latter, we face problems of identification.

The next section focuses on the policy instruments governments commonly employ to intervene in their economies. This discussion is first carried out in a broad context based on the experience of a large number of countries. Then, to provide depth, a more detailed and narrow-based analysis of interventions in the Dominican Republic is presented. This section concludes with a brief discussion of some of the important economic implications of these interventions to trade and growth. To provide some insight into the motivation for government intervention in ways that appear detrimental to the growth process and the "stickiness" of these interventions to changes in a countries economic environment, the discussion of section III focuses on a growing body of literature that Colander has termed neoclassical political economy (11). In the latter part of this section, we again narrow our focus to characterize a class of economic models which has as its common core, endogenous government behavior with rent-seeking households. A summary concludes the paper.

Policy Instruments and Their Manipulation

Analyses of countries' reactions to the 1973-74 and 1979-80 shocks to world markets provide insight into the different policies pursued by the OOC's and IOC's (4). The OOC, because of their greater exposure to world markets (28 percent of gross national product (GNP), compared with 10 percent for IOC), suffered larger terms-of-trade effects and adverse export volume effects than did the IOC. The policy response of the OOC was to apply deflationary policies to limit their reliance on external finance. They also pursued output-increasing and efficient import substitution policies. These adjustments served to compensate for the adverse balance-of-payments effects of external shocks and reversed the temporary decline in their economic growth. While many of these countries (such as Korea) have relatively high-external debt to GNP ratios, they have managed to avoid debt service difficulties.

It was the IOC, many of which are major importers of U.S. agricultural commodities, that ran into difficulties. Inward-oriented countries tended to pursue policies to maintain internal market distortions despite world market shocks. In general, the policies pursued by many of the IOC served to transfer resources from agriculture into (1) inefficient import substitution activities, (2) activities that tended to lower the cost of wage goods, namely food, and (3) into government programs, projects, and state-owned enterprises, many of which were not socially profitable (27). These transfers were, in part, accomplished by interventions in

foreign trade markets where quotas, tariffs, export taxes, and exchange rates are effective policy instruments. Results from a recent International Monetary Fund (IMF) study of developing countries found that the average effective rates of protection in manufacturing were 50 percent during 1966-72 and 60 percent in the late seventies (16). Many countries that have high rates of protection for manufacturers frequently allow imports of raw materials intended for export production to enter duty free (16, p. 74).

These instruments are often used to protect the industrial sector from competing imports. This serves to distort the domestic terms of trade against agriculture because those sectors receiving preferential treatment are made to appear profitable relative to agriculture. In many countries (Egypt, Tanzania, Peru, Philippines, Zaire, and others), these instruments were also used to maintain low and stable prices of food through excessive imports relative to import levels under free trade or to discourage the export of food crops for which a country has a comparative advantage (7,12,23,31). Furthermore, primary exportable commodities tended to be heavily taxed in many countries.

Interventions are not restricted to these markets. Interventions in domestic capital markets have given rise to negative real interest rates, in part, because nominal rates remain fixed during periods of high inflation. At various times during the seventies, negative real interest rates were particularly large in Brazil, Ghana, Jamaica, Nigeria, Peru, and Turkey (35, p. 58). The experiences documented by Balassa (4) for Brazil and Turkey and Carbo de Melo and Tybout (11) for the Latin American countries of the southern cone support the view that the effects of below equilibrium real interest rates tend to lower the efficiency of investment by discriminating among capital users, to favor the application of capital intensive techniques, to discourage domestic savings, and to encourage capital outflow. These effects have encouraged many countries to rely on external sources of finance.

Controls on nominal exchange rates and foreign exchange allocations have clearly been important policy instruments for many countries. A common characteristic among the IOC is that they tend to have overvalued real exchange rates. For the most part, there seems to be general agreement that an overvalued real exchange rate is (1) effective in discriminating against agriculture (an important source of foreign exchange earnings in many countries), (2) a stimulus to imports, (3) a destabilizing element to a country's capital account, and (4) a factor inducing protection against imports.

Monetary and fiscal policy, foreign trade policy, and direct sectoral interventions of the form discussed are among the determinants of real exchange rates. But, the form of the exchange regime is also important. As emphasized by Krueger, most developing countries have employed quantitative restrictions on current accounts and, in many cases, severe restrictions on capital flows (18). In the case of exchange control regimes, the nominal exchange rate takes on a more important role as a policy instrument because the domestic price of importable commodities is cut off from the world price. Given an increase in the domestic price level, the domestic price of exportable commodities relative to import-competing goods will tend to fall. The nominal exchange rate becomes important because it determines the degree to which the relative price of import-competing goods exceeds their world relative price.

The experience of the southern cone countries (Argentina, Chile, and Uruguay) is notable for the initial success and then apparent failure of policy reforms (11). Prior to the 1974-76, all three countries faced highly protected economies where interest rates had been controlled for decades, price controls had been in place since the early fifties and labor markets had been subject to innumerable regulations. Corbo and others suggested that earlier but abandoned attempts at deregulation "implied that the authorities probably faced deeply entrenched political interest groups and recalcitrant expectations (9, p. 636)."

The initial results of liberalization were remarkable. In Argentina, the central government budget deficit was reduced from an average of 12 percent of gross domestic product (GDP) in

the pre-reform crises period to 8 percent, and inflation was cut in half. In Chile, the government budget deficit was reduced from 16 percent of GDP to 1 percent, and inflation was halved. Uruguay experienced 8 years of rapid growth with declining government budget deficits and declining rates of inflation.

Corbo and others suggested that the new policy regimes created a boom-bust cycle so that with the change in world environment of the early eighties, the economies of these countries collapsed (11). This resulted in the abandonment of the liberalization effort that they attributed to policy inconsistencies focused on: a lack of fiscal restraint (Argentina and Uruguay), the indexation of wages (Chile), and the confusing management of the exchange rate. Each country experienced an accumulation of external debt and rising real exchange rates in the early eighties, which ultimately led to discrimination against exports. Moreover, they argued that the microeconomic reforms of both the commercial and financial sectors failed to eliminate important distortions.

Interventions in foreign trade markets that induce a transfer of resources from agriculture invariably lead to depressed conditions in the sector. Some governments seem to react to these depressed conditions by developing policies to subsidize agricultural inputs and policies to raise farm-level commodity prices, while at the same time maintaining low and stable food prices to urban consumers. These policies lead to a narrowing of the marketing margin and, in some countries (such as Egypt and Peru), they lead to farm-level prices that are higher than their retail market counterparts (23,33).[3]

Without subsidies, the narrowing of the margin implies lower returns to the resources employed in marketing activities and, hence, to an exodus of merchants and middlemen traditionally involved in these activities. The implementation of the policy often leads to the taking over of marketing functions by government agencies and state-owned enterprises.

The direct budgetary expenditures to subsidize marketing activities are often augmented by additional losses generated by inefficient state-owned enterprises. The contribution that many state-owned enterprises make to the central government's budget deficit can be large (31). Estimates of losses associated with state-owned enterprises of all types in seven countries ranged from a low of less than 1 percent of GNP in Korea to over 10 percent of GNP is Sri Lanka (29).

The Dominican Republic

To provide more depth to the general remarks above, we summarized some of the key results from an on-going study by Greene and Roe of the political economy of agricultural prices in the Dominican Republic during the 1966-85 period (13). We focused on three major crops; rice, which was imported in eleven of the past 20 years, and the two major export crops, sugar and coffee. These crops comprised about 54 percent of the total annual value of agricultural production between 1982-84 of which sugar and coffee accounted for over 40 percent.

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[3]Some insight into the pervasiveness of production and product marketing controls can be obtained from a USDA/University of Minnesota study of food policies in 21 developing countries (32). The study found that all 21 countries employed some type of domestic production or marketing controls for food grains. These included control of procurement, processing, storage, and transportation. The countries implemented these controls through licensing, subsidy schemes to middlemen (primarily at wholesale), and through support of state-owned enterprises. The extent of control in a country tended to be in direct proportion to the expenditure share of the crop in household consumption. Eighteen countries imposed marketing controls on wheat, 19 imposed controls on rice, 13 imposed controls on maize, and 14 imposed controls on sorghum. The African countries in the study tended to employ the largest array of controls over the most crops, followed by Asian countries and the Latin American countries.

The recent economic history of the Dominican Republic can be summarized as follows. Since the 1973-74 shock to world markets, the economic performance of the country's economy has slowly deteriorated, reaching a point in 1983 where debt rescheduling negotiations with the IMF resulted in agreement on a series of steps to liberalize the economy. Agriculture has declined from about 30 percent of the country's GDP in 1966 to about 18 percent in 1984. Annual real rates of growth in agriculture's. GDP has averaged about 0.7 percent, while the overall economy grew at about 3.3 percent between 1974-84. Government budget deficits averaged around 5.6 percent of GDP since 1977. By Latin American standards, the rate of inflation has been low, 24.5 percent in 1984 and 37.5 percent in 1985. Nevertheless, inflation has resulted in negative real interest rates on savings deposits in 9 out of the past 14 years. The country's trade deficit grew at an annual average rate of about 22 percent during 1977-83, reaching a high of US$669.8 million in 1980 when exports of goods and services were only about 60 percent of imports. Concomitant with the rising deficit, the country's parallel market for peso-dollar exchange diverged from the official 1-to-1 rate by about 25 percent in 1982, accelerated to a divergence of over 50 percent in 1983, and then to 180 percent in 1984. During this period, exports declined from 25 percent of the county's real GDP to less than 15 percent in 1982. An outcome of the IMF negotiations was a unification of the parallel and official rate in 1985 at 3.12 pesos to the U.S. dollar.

The state-owned sugar mills (CEA and INESPRE), the state-owned marketing and import monopoly for rice, corn, and other commodities play key roles in implementing the country's price policy. These enterprises have incurred large deficits in recent years. As the sole marketing agent, INESPRE influences prices at various levels in the marketing chain by engaging in domestic and foreign market transactions until markets clear at announced prices. In September 1986, authority for rice marketing was transferred from INESPRE to the agricultural bank in an effort to reduce the degree of intervention in rice marketing.

Estimates of nominal producer and consumer rates of protection for rice, sugar, and coffee are reported in table 1. These estimates are referred to as the "direct effects" of government intervention on the domestic prices of these crops relative to their border price counterparts. Estimates of the total relative rates of protection (from now on referred to as "total effect") are reported in table 2. The total effect takes into account the effects of the equilibrium peso to dollar rate of exchange and the direct effects. The numeraire for domestic farm prices is the price index of nonfood goods. The numeraire for border prices is the nonfood price index where its trade component has been adjusted for implicit tariffs and the peso-dollar rate of exchange. The equilibrium rate of peso-to-dollar exchange is an estimate of the rate that would prevail in the absence of implicit taxes and tariffs. In most years, the estimated equilibrium rate corresponds closely to the peso-dollar rate reported in the peso-dollar parallel market (27).

A comparison of the two tables shows that the direct effects amounted to a subsidy (tax) to the producers (consumers) of rice in most years. The direct effects on the export crops of sugar and coffee suggest that in most years the producers of these crops were taxed. Consumers received an implicit subsidy on coffee, but their consumption of sugar was implicitly taxed. However, when the total effects are taken into account, the implicit tax (subsidy) on producers (consumers) of these crops increase substantially.

The increase in implicit taxes and subsidies is attributable to two factors. First, the equilibrium exchange rate had the effect of (1) raising the border price of each respective crop and (2) raising the trade component of the price index of nonfood goods, that is the numeraire. The increase in the border price of the respective crops has the effect of increasing the estimate of the implicit tax (subsidy) to producers (consumers), while the increase in the trade component of the price index of nonfood goods tends to decrease the tax (subsidy) to producers (consumers).

Table 1--Direct nominal rates of protection, Dominican Republic

Year	Producer			Consumer		
	Rice (1)	Sugar (2)	Coffee (3)	Rice (4)	Sugar (5)	Coffee (6)
			Percent			
1966	15.1	1/	2.2	-3.1	45.6	16.5
1967	15.7	1/	-0.5	2.5	37.4	16.7
1968	43.0	1/	2.8	23.8	45.9	11.7
1969	36.2	80.4	1.3	26.0	74.2	10.4
1970	22.5	31.3	-23.8	24.0	81.7	-14.6
1971	22.0	7.0	-2.0	16.2	95.8	-7.3
1972	4.2	-9.2	-14.8	14.1	110.0	-15.1
1973	-34.0	-25.4	-16.1	-41.0	121.8	-12.8
1974	-34.0	-48.3	-5.3	-25.2	169.8	-0.5
1975	11.2	-56.7	-5.9	23.6	272.2	-22.6
1976	42.9	-70.1	-19.8	40.8	234.4	-11.4
1977	23.9	-54.4	-21.2	18.2	133.6	-16.0
1978	23.2	-39.9	-3.4	9.3	119.7	-15.1
1979	35.9	16.3	-23.2	6.8	64.6	-21.6
1980	8.4	71.6	-4.3	6.4	59.2	3.0
1981	7.1	-53.7	7.4	6.7	189.4	0.0
1982	92.3	-4.0	-27.2	38.6	96.1	-19.0
1983	90.0	201.4	-26.1	45.0	55.7	-16.4
1984	-2.1	91.8	-31.1	-31.6	55.1	-15.0
1985	60.4	440.0	-74.7	-17.3	39.1	-40.0

Note: Nominal rate of protetction equals [P9i) - Pb(i)]/Pb(i) where P(i) is the price of the i-th crop Pb(i) denotes the border price of the i-th crop in pesos evaluated at the official rate of peso-dollar exchange. Adjustments have been made to account for domestic processing, marketing, and transportation costs so that the relevant farm level to border price equivalent prevails.

Column (2) estimates are based on the world market price for sugar (market 11), not the weighted average price between the U.S. market (market 12) and market 11.

Column (5) estimates are also based on the market 11 equivalent price. If the weighted market 12 and 11 prices had been taken as the opportunity cost prices, then the direct effect would have been negative (subsidy) in many years.

1/ Market 11 price was less than the shutdown price for sugar.

Source: (13, various tables).

Second is the impact of the tariff and quota equivalent tariff effect on the price index of nonfood goods. Adjustments to the trade component of the price index of nonfood goods to account for these effects tend, in most years, to dominate the increasing exchange rate effect [(2) above] on the trade component of the nonfood price index.

Thus, protection of the domestic nonfood sector through tariffs and quota restrictions on trade in nonfood goods exceeded the opposite effect on the index attributable to an overvalued rate of peso-dollar exchange. Consequently, the total effects reversed what was otherwise an implicit subsidy (tax) to rice producers (consumers). Total effects also served to exacerbate the implicit tax (subsidy) on producers (consumers) of these crops, while at the same time increasing the protection to producers of nonfood import substitutes and taxing consumption (both urban and rural) of the import-substitute goods. These additional effects came about because of the overvalued exchange rate and the effects on nonfood goods of tariffs and quotas.

The partial equilibrium welfare effects (measured as changes in Marshallian consumers surplus and quasi-rents) of the total effect of the interventions are reported as a percentage of agricultural GDP in table 3. These estimates are based on an estimated system of complete demand elasticities (35) and on estimated supply elasticities for rice, sugar, and coffee (13).

Table 2--Total relative rates of protection, Dominican Republic.

Year	Producer			Consumer		
	Rice/ PNA (1)	Sugar/ PNA (2)	Coffee/ PNA (3)	Rice/ PNA (4)	Sugar/ PNA (5)	Coffee/ PNA (6)
	Percent					
1966	-17.0	1/	-28.7	-30.2	128.0	-16.0
1967	-15.3	1/	-29.6	-24.9	186.3	-14.6
1968	4.2	1/	-27.8	-9.8	116.1	-18.6
1969	-1.0	-1.0	-29.2	-8.4	15.1	-19.8
1970	-11.0	-23.3	-46.3	-9.9	3.1	-38.0
1971	-12.5	-35.9	-33.3	-16.6	-10.7	-33.5
1972	-19.8	-37.2	-35.8	-12.1	-15.8	-35.0
1973	-48.7	-47.2	-36.2	-54.1	-25.7	-32.3
1974	-46.6	-59.7	-25.1	-39.5	-34.7	-19.4
1975	-4.9	-63.6	-20.7	5.8	-61.3	-33.8
1976	16.8	-76.3	-35.2	15.1	-58.6	-27.6
1977	1.7	-64.7	-35.8	-3.0	-33.5	-31.0
1978	-5.6	-58.5	-27.1	-16.3	-38.3	-35.0
1979	2.3	-33.4	-43.0	-19.6	-14.1	-41.0
1980	-19.4	2.5	-30.7	-20.9	-28.0	-23.7
1981	-18.3	-66.2	-20.5	-18.6	-76.4	-23.7
1982	27.4	-46.9	-53.6	-8.2	-60.3	-46.3
1983	12.4	-2.4	-58.5	-14.2	-44.4	-50.6
1984	-10.3	-48.2	-69.5	-37.3	-70.3	-59.3
1985	46.3	367.4	-77.0	-24.6	-71.5	-45.3

Note: Total relative rate of protection equals: [P9i)/PNA - P*(i)/PNA*]/[p*(i)/PNA*] where P*(i) denotes the border price of the i-th crop evaulated at the estimated equilibruim rate of peso-dollar exchange, PNA denotes the price index of nonfood goods and PNA* denotes the price index of nonfood goods where adjustments are made for the exchange rate and implicit taxes on the trade component of the index.

Column (2) estimates are based on the world market price for sugar (market 11), not weight average price between the U.S. market (market 12) and market 11.

Column (5) estimates are also based on the market 11 equivalent price. If the weighted market 12 and 11 prices had been taken as the opportunity cost prices, then the direct effect would have been negative (subsidy) in many years.

1/ Market 11 price was less than the shutdown price for sugar.

Source: (13, various tables).

Gains and losses are not reported in these estimates of quasi rents to merchants, middlemen, and state-owned enterprises, which comprise the vertical markets between primary producers and final consumers of these crops.

The results in table 3 suggest that the implicit transfers from the producers of these crops were large. The largest magnitudes correspond to those years when one or more of the three crops were experiencing high relative border prices. The total implicit annual transfers to consumers (column (4), table 3) were positive since about 1970 and, on average, amounted to about 4 percent of agriculture's GDP. Relative to the transfers from producers, these magnitudes seem small. However, it should be kept in mind that sugar and coffee are primarily exported. Hence, the total implicit transfer from producers exceeds the transfer to consumers.

Column (5) of table 3 shows the estimated total effect of interventions in these crops on the country's foreign exchange earnings. Clearly, interventions have served to increase consumption of traded goods, decrease their supply, and caused the country to forego foreign exchange earnings amounting to an average of over 21 percent of the annual value of imports during 1973-84.

Table 3--Estimated transfers to (+) and from (-) producers, consumers, and foreign exchange earnings based on total relative rates of protection, Dominican Republic.

Year	Transfers to-- Producers		Consumers		Foreign exchange loss to exporters
	(1)	(2)	(3)	(4)	(5)
	DR$	Percent	DR$	Percents	
1966	61.5	5.3	-11.7	-1.0	-7.2
1967	109.2	9.7	-42.9	-3.8	-5.3
1968	72.0	5.3	-45.9	-3.4	16.5
1969	-33.2	-2.3	-5.5	-.4	4.8
1970	-156.9	-10.5	6.5	.4	1.7
1971	-195.2	-12.3	26.7	1.7	5.9
1972	-226.0	-12.4	17.6	1.0	1.5
1973	-471.4	-23.5	153.9	7.7	-21.0
1974	-828.5	-39.2	138.5	6.6	-27.0
1975	-894.9	-48.8	54.0	2.9	-19.0
1976	-1155.5	-55.8	24.3	1.2	-32.8
1977	-576.2	-33.2	21.1	1.2	-16.9
1978	464.8	-25.1	59.3	3.2	-26.9
1979	-275.0	-14.9	16.5	.9	-15.1
1980	-98.3	-5.9	30.3	1.8	-14.9
1981	-799.2	-50.8	118.2	7.5	-19.8
1982	-358.9	-23.5	47.6	3.1	-26.0
1983	-93.6	6.2	38.1	2.5	-19.2
1984	-430.6	-28.0	128.9	8.4	-16.8
1985	11.4	.9	67.7	5.2	NA

NA = Not available.

Note: Column (1) equals the sum of quasi-rents based on estimated supply functions for rice, sugar, and coffee and the total price effects reported in table 2. Cloumn (3) equals Marshallian consumers surplus based on a complete system of estimated consumer demand elasticities and total price effects reported in table 2. Columns (2) and (4) express these results as a percentage of agricultural GDP at constant 1984 prices. Column (5) expresses the change in the US$ value of foreign trade in rice, sugar, and coffee from the results in table 2 as a percentage of the value of actual exports. Columns (1) and (3) are in constant 1984 DR$.

Source: (13, various tables).

While these results imply that government policy served to transfer resources out of agriculture, consideration should also be given to the government transfers into agriculture. These estimates, while only approximate, are provided in table 4. Column (1) and (2) of the table are the sum of current and capital expenditures identified in government accounts as agricultural expenditures by central government and autonomous government institutions, exclusive of CEA and INESPRE. Of course, these expenditures include salaries, administrative costs, and payments for activities that may only be indirectly related to agriculture and, in many cases, activities that are carried out in urban areas. The largest portion of the expenditures include the country's agrarian reform program, maintenance and investments in irrigation, rural roads and agricultural extension.

Columns (3) and (4) of table 4 report the annual fiscal surplus and deficits of CEA and INESPRE's rice marketing activities, respectively. A surplus is treated as an annual transfer of resources from agriculture; a deficit is treated as a transfer to agriculture. A deficit could be related to subsidies passed on to consumers from absorbing the costs of carrying out marketing functions.

Data in column (6) suggest that transfers to agriculture as a percentage of agriculture's GDP have averaged about 23 percent over the period 1974-84. However, the implicit transfers out of agriculture, based on the estimates of the total effects of government interventions,

Table 4--Transfers into and out of agriculture, Dominican Republic

Year	Expenditure		Fiscal accounts		Direct transfers to agriculture	Share of GDP agriculture	
	Current (1)	Capital (2)	CEA (3)	INESPRE (4)	(5)	Transfers to agri.1/ (6)	Quasi-rent 2/ (7)
	Million DR$ 3/					Percent	
1966	NA	NA	NA	NA	NA	NA	5.27
1967	NA	NA	NA	NA	NA	NA	9.73
1968	61.81	43.96	NA	NA	105.77	7.75	5.27
1969	90.82	17.22	NA	NA	108.04	7.52	-2.31
1970	96.36	85.97	-19.58	0	201.95	13.47	-10.47
1971	115.88	117.87	-2.00	30.80	204.95	12.96	-12.34
1972	110.23	125.72	-.74	15.19	221.51	12.15	-12.34
1973	91.63	165.95	30.65	36.45	190.48	9.51	-23.54
1974	101.05	287.15	28.89	-89.72	449.03	32.26	-39.22
1975	104.38	386.87	89.25	34.75	367.25	20.01	-48.76
1976	143.53	277.19	-20.68	14.55	426.86	20.60	-55.77
1977	137.16	242.33	73.06	-37.35	344.05	19.80	-33.16
1978	139.96	281.89	-67.84	-9.80	499.50	26.95	-25.08
1979	198.88	205.83	-43.57	70.71	577.57	20.45	-14.89
1980	188.31	196.63	-170.46	-5.23	560.63	33.45	-5.87
1981	180.91	275.51	-79.29	-83.71	619.42	39.34	-50.76
1982	152.11	147.18	-143.33	1.60	441.02	28.65	-23.32
1983	156.06	156.47	-96.88	-13.25	431.66	28.64	-6.21
1984	171.81	152.70	-15.50	-43.20	383.21	24.93	-28.02

NA = Not available.
1/ Column (6) is (5) as percentage of agricultural GDP.
2/ Column (7) is quasi-rents based total effects as percentage of Agriculture GDP.
3/ Constant 1984 DR$.

Source: (13).

averaged over 30 percent of agriculture's GDP over the same period. These results omit dead weight losses. If the transfers back to agriculture yield a net social rate of return lower than the social rate of return to the same resources employed by producers, then the transfer is effectively less than the 23-percent estimate. In any case, it appears that interventions have served, on net, to transfer resources from the sector.

These results suggest that interventions in other sectors of the Dominican Republic's economy have also served to increase the tax on agriculture. In many countries, the policy decisionmaking process is not characterized as a hierarchical system of control; instead, various public organizations often have some degree of autonomy (particularly state-owned enterprises (SOE)) with associated principal agent problems. CEA, INESPRE, and the ministry of agriculture tend to be associated with interventions that, for the most part, relate to the direct effects reported in table 1.

It can be conjectured that the main political activity of rural producer groups to lobby for higher prices was through these organizations. Hence, their efforts toward seeking a differential advantage came about through direct effects. Urban groups, composed of urban households and import-competing industrialists, focused on trade and exchange rate policies to seek their differential advantage. The welfare of urban households was consistent with those of domestic industrialists who benefited from an overvalued exchange rate and import tariffs and quotas. While urban households may have been a "free rider" to the coalition of urban import-competing industrialists during the early seventies and eighties, their support of this coalition is suggested by the urban riots in April 1984, which led to the death of about 100 people. This protest was in response to the government's announcement to discontinue the sale of foreign exchange at the official exchange rate for food.

Policy Intervention

The direct effects of interventions give rise to a host of indirect effects. The indirect effects come about, in part, because interventions have contributed to increased government expenditures with corresponding increased deficits. Often associated with a country's expenditures is an increase in currency stocks, an increase in inflation, a decrease in real interest rates, and a declining real exchange rate. A decline in the real exchange rate serves to further increase the implicit subsidy to imports, to tax exports, and to induce deficits on a country's trade account. Since agriculture is a major export sector in many developing countries, these interventions serve to extract resources from agriculture. The resulting decline in foreign exchange earnings has induced some countries (such as Indonesia, Egypt, and Tanzania) to respond by postponing the import of capital goods and raw materials, which, in turn, has also had deleterious effects on the output of industrial goods (20,24,31). Hence, these interventions tend to decrease export shares, while at the same time increasing a country's demand for external finance. Moreover, the accumulation of external debt is not, in general, allocated to socially profitable investments, but to cover fiscal deficits, the maintenance of inefficient import substitution activities and to finance SOE activity that could be more efficiently carried out by private enterprise. [4]

The relationship between government induced market distortions and the rate of economic growth is far more complicated than the confines of this paper permit us to explore. Numerous studies (Krueger (19) and Cavallo and others (9) background papers to the 1986 World Development Report) provide evidence that shows that the growth rate has responded to the removal of trade barriers, that growth is negatively correlated with exchange rate misalignment, and that increased instability in exchange rates is negatively correlated with investments in many countries. As Lucas (21) points out, these effects should perhaps be treated as off-equilibrium growth path effects, that is, level effects. The level effects from the removal of distortions should not be confused with equilibrium growth path effects that are a more fundamental and, in our view, a more complex issue.[5]

Lucas suggests that factors affecting the equilibrium growth rate are predominantly associated with externalities (21). The extent to which governments become preoccupied with interventions in sectors of their economies where markets are relatively efficient in the allocation of scarce resources, the more likely they are to underinvest in aligning the net social rates of returns in activities where externalities are present.

This "underinvestment" effect is likely exacerbated by three additional factors. First, distortions in an economy make the identification and computation of distortion adjusted shadow prices on public investments a complex process. Hence, errors of under investment can easily be made because, particularly for agriculture, distortions almost always lower the unadjusted estimates of the net social rate of return to these activities.

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[4]Additional indirect evidence reported by the IMF (16, p. 89) suggests that IOC's, which eventually experienced debt-servicing problems, had earlier experienced declining domestic savings rates. Their declining output-capital ratios over this period suggest a decrease in the efficiency of their investments and, relative to the OOC's, the tendency to use borrowed funds in such a way that does not increase the economy's capacity to generate foreign exchange.

[5]The possibility that externalities are an important key to the equilibrium rate of growth (and hence economic development, with an explicit role for government) led Lucas to extend the Solow model to account for an individual productivity effect of learning by doing on own resources and to have an external effect on the productivity of all other resources. In this set up, human capital accumulation is taken to be specific to the production of particular goods. Because the individual human capital contribution to the productivity of other resources is not perceptible, nor can the individual capture the return to this external effect, an equilibrium growth path and an optimal growth path can be obtained from the model. If different goods are taken to have different potentials for human capital growth, then the same considerations of comparative advantage that determine which goods get produced will also dictate each country's rate of human capital growth. The model admits the possibility of wide and sustained differences in growth rates across countries, differences that one would not expect to be systematically linked to each country's initial capital levels.

Second, as evidence from the IOC indicate, extensive interventions almost always yield fiscal deficits in central government accounts. Hence, from the perspective of public planning authorities, additional resources allocated to activities where externalities are present means, in light of distortions already in place, inducing further distortions or to draw upon already extended sources of external credit to obtain extra public funds.[6] In the presence of distortions, the opportunity cost of additional public funds is likely to be quite high.

Third, many developing countries are characterized by poor institutional development, which inhibit the existence and manipulation of first-best policy instruments, an example of which might be a value-added tax. Obtaining additional funds often implies the manipulation of second-best policy instruments, which raises the net social opportunity cost of public investments.

Market Interventions and Government Behavior

Insights into the motivation for government intervention are provided in a growing body of literature that Colander termed neoclassical political economy (10). The key strands of this literature are distinguished by the more "informal" theories of the political science school typified most recently by Bates' (5) research on the behavior of governments in East Africa and by Mancur Olson on distributional coalitions and the free-rider problem. "Formal" theories have been developed by the public choice school, by Buchanan (8) and the field of trade and development where emphasis is placed on rent seeking by (Krueger (19)) or, as Bhagwati (7) has suggested, on directly unproductive profit-seeking (DUP) activities. We draw selectively on this literature for what we view to be some of the more important insights within the context of this paper. Given the complexity of motivations and means for government intervention, the insights provided are based on observation and deduction rather than formal empirical analysis.

Bates (5, p. 169) views public policy as the outcome of political pressures exerted by members of the domestic economy seeking their own interests. In the case of developing countries, he argues that this view is consistent with the observation that urban consumers are potent pressure groups demanding low-priced food. They have political influence because of their geographical concentration and strategic location. They can quickly organize, and they are largely employed in providing public services so they can, with relative ease, impose deprivation on others. Bates notes that urban unrest forms a significant prelude to changes of governments in Africa (5).

Interests of urban consumers coincide with those of domestic industrialists who view low-priced food as serving to decrease the pressure on wages. The industrialists also are effective in obtaining protection from imports because of the notion that the key to development lies in industrialization. Since industrial goods account for a small share of most households' budgets in LDC's, import protection of industrial goods will not have a large direct impact on expenditures of most households. The outcomes are policies that tend to support both import substitution and low-cost food to urban households.

The same argument applies to developed economies. In advanced stages of development, the food share of the consumer's budget declines so that consumers become less sensitive to increases in food prices. Agriculture becomes a smaller component in the total economy and farmers tend to be more specialized. Within their area of specialization, farmers are better

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[6] In countries that face binding budget constraints, the targeting of foreign aid to activities where externalities are present would seem to be more socially optimal than to target foreign aid to activities that induce government to intervene in sectors of their economies where markets are reasonably efficient in the allocation of scarce resources. Egypt is an example where foreign aid increased the public sector's grain storage capacity.

able to organize than are urban groups. With food a small share of consumer's expenditures, protection demands in agriculture can be met at lower political cost with the result that the agricultural sector receives more protection than the industrial sector.

Honma and Hayami (15) and Anderson (2,3) provide some empirical support of this general view and extend it to explain why policy regimes in developed countries tend to protect agriculture and regimes in developing countries tend to tax agriculture. Anderson (3) notes in his study of the growth of agricultural protectionism in east Asia that countries tend to switch from taxing agriculture to taxing manufacturing in the course of economic development. The timing of this switch is associated with agriculture's declining comparative advantage relative to manufacturing. Anderson draws upon Down's concept of the political market for policies where the demanders of policy interventions are the potential beneficiaries and the political leadership is the supplier of policy interventions. The result is consistent with that of Bates (5). When food accounts for a large share of the consumer's budget relative to manufactured goods, the political cost of obtaining additional support for agriculture is high relative to additional support for food deficit households and manufacturers. Hence, policies that are carried out tend to tax agriculture relative to manufacturers.

While these arguments provide insight into the motivation for interventions, why do governments prefer to intervene in markets that would perform relatively well if left alone? They could accomplish the same objectives in areas where markets function poorly. Bates argues that market interventions facilitate the allocation of political rents (5). Market interventions permit governments to target the allocation of subsidies through control of the marketing functions, while, at the same time, transferring resources to supporters (civil servants) engaged in carrying out these interventions. In Bates' terminology, market interventions facilitate the "organization of the rural constituency" who supports the government and "disorganize the rural opposition."

Olson focuses attention on the formation of special interest groups into coalitions and on their role in obtaining a differential advantage through lobbying activities. He tends to emphasize the behavior of individual interests on the nature and behavior of the coalition. Important among the inferences he draws are that: broad-based coalitions tend to take into account the adverse macroeconomic effects of their lobbying efforts so that the adverse effects of the differential advantage they seek tends to be less than narrow-based coalitions. Narrow-based coalitions tend to be more interested in the distribution of society's income to members of the coalition since resources to expand societies output have to be shared with the rest of society, while the benefits of the same resources spent on redistributing society's output in its favor accrue entirely to the group. The policy instruments that narrow-based coalitions influence or control tend to be sticky to changes in economic conditions. The stickiness arises because of the need to negotiate the implications of changing economic conditions within and between various interest groups. This has the effect of increasing the time required to respond to economic shocks.[7]

The literature on DUP or rent-seeking activities offers a point of departure for obtaining empirical insights into the factors motivating government intervention than does the more informal, but perhaps broader based theories of Bates and others.[8] Starting with this approach, we posit a simplified model of endogenous government behavior with rent-seeking households.

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[7]Pryor attempted to obtain empirical support for the overall implication of Olson's theory, namely that economies characterized by broad-based coalitions should out per form economies characterized by narrow based coalitions (24,25). He concludes that ... "Olson's theory is formulated in a manner still too general to prove successful in the empirical tests..."

[8]An excellent review of this literature is provided by Bhagwati (7). A review and some extensions also appear in Colander (10).

Consider the case of a two-good, two-household rural-urban economy that takes its external terms of trade as given. The government in this economy is assumed to announce prices (P_a, P_n) of the rural and urban goods and to engage in domestic and foreign trade until markets clear.[9]

Household choices are defined by:

$$\underset{[q_{ai}, q_{ni}, a_i]}{\text{Max}} \quad V_i = V_i(q_{ai}, q_{ni})$$

subject to

$$(1) \quad Q_i P_i - a_i = P_a q_{ai} + P_n q_{ni}$$

where the index i = a (rural), n (urban) denotes households, $V_i(.)$ is the household's direct utility function, q_{ai} and q_{ni} are quantities consumed of the rural and urban good by the i-th household, and Q_i is the i-th household's endowment of the rural (i = a) and urban (i = n) good. Hence, there is no production in this version of the model.

In this simplified model, the choice variable a_i is most unambiguously viewed as a bribe. It could also be viewed as expenditures allocated to the process of lobbying, negotiating, and other activities involved in influencing political authorities.

In our more general specification, a_i is a vector of inputs allocated to lobbying and other rent-seeking activities. The reallocation of inputs from production to lobbying and other directly unproductive activities (DUP) can provide pecuniary returns to individual households, but it can be socially wasteful.[10]

Before households can choose a_i, they must know the effect of the bribe on the government's choice of levels for the instruments P_a and P_n. If the choice of a_n results in an increase in P_n relative to P_a, then urban households can be better off than rural households whose endowment Q_a is in rural produced goods. Hence, in principal, a Cournot-Nash game exists between rural and urban households.

The government is assumed to form preferences over households. For simplicity, we denote these preferences in terms of U:

$$(2) \quad U = I_a V_a + I_n V_n + I_f V_f(R)$$

where V_a and V_n are the utility of rural and urban households defined above and, for our purposes here, V_f is the utility of an aggregate of next period households.[11] The I_i is an influence function that defines the parameters of equation (2), and hence, the government's preference ordering. These are defined below. R is the budgetary consequence of government interventions:

$$R = (1-P_a)(Q_a - q_{aa} - q_{an}) + (P_n - 1)(q_{nn} + q_{na} - Q_n)$$

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[9]This assumption is somewhat arbitrary. Other instruments, such as ad valorem taxes or tariffs, could also have been chosen as policy instruments.

[10]DUP activities in these models can be welfare improving if the intitial point of departure is from a distorted economy, as in the case of Krueger's pioneering article (19).

[11]A more general formulation is $U(V_a, V_n; I_1) + U(V_f(R; I_2))$. However, this complicates the specification of the properties of the influence functions I_i. Moreover, it is unlikely that the hierarchial structure of a policy decisionmaking process in a county is sufficiently free of principal agent problems that it can be express by a single objective function. Instead, each decisionmaking unit of government may seek pecuniary gains subject to budget and legal constraints.

where border prices are unity. If the government does not discriminate over households, then domestic prices are unity and R is zero. Hence, a choice of prices P_a and P_n that subsidize current period households (R negative) are treated as a lump sum claim on or an income transfer from the next period households.[12] In this static version of the model, we treat the variables (except R) of the indirect utility functions of future households as predetermined.[13]

The relationship between the influence functions I_i and bribes are adapted from Becker. We only sketch their properties here. Influence functions (I_a, I_n) depict the political influence of the pressure (denoted p_a, p_n) applied by rural and urban households to obtain subsidies or avoid taxes. These functions have the properties:

$$I_a + I_n + I_f = 1,\ 0 < I_j < 1, \text{ and } -I_a/p = I_n/p$$

where, because of the static version of the model, I_f is predetermined and $p = p_a/p_n$ (that is, the ratio of pressure applied by rural and urban households, respectively).[14] These conditions imply that the pressure exerted by urban households lowers the pressure exerted by rural households.

The pressure functions (p_a, p_n) are akin to the technology that translate the allocation of resources (bribes in our case) into pressure. Becker's specifications also accounts for the relative size of a group and the problem of free riders within a group. In the context of our model (a single household), the pressure functions can be simply specified as a function of bribes:

$$p_i = f_i(a_i), \text{ for } i = a, n.$$

The function f_i defines the technology of converting bribes into pressure.

The decision rules for the government's policy instruments P_a and P_n can be obtained by assuming that the government chooses these instruments as though it sought to maximize equation (2). The exogenous variables in the government's policy "decision rules" include the level of bribes, a_a and a_n. Denote these "decision rules" as

$$(3)\ P_a = P_a(a_a, a_n)$$

$$(4)\ P_n = P_n(a_a, a_n).$$

We can now return to the households' problem. Assuming that households correctly perceive the objective of government, equation (2), know the political process through the influence functions and the technology reflected in the pressure functions, equations (3) and (4) can be substituted into the household's budget constraint equation (1). Except for the knowledge or assumptions of the bribing behavior of the other household (that is, the game component of the problem), the i-th household is now in a position to choose q_{ai}, q_{ni} and a_i. It can be shown that the household chooses a_i to maximize income.

The essential characteristic of the phenomena of DUP activities depicted in this framework is that an environment exists where it is rational for individuals to allocate resources in search

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[12] A more elaborate model would treat this as a dynamic problem where the government makes choices over some continuum of time with explicit account taken of fiscal, monetary, and domestic and world capital market opportunities to deal with surplus or deficits in R.

[13] The government's choices of P_a and P_n only affect current period markets. A dynamic version of the model would require an expectation formation mechanism to forecast future bribes, and, therefore, the preference weights over future households.

[14] An example of a functional form satisfying this condition is: $I_a = (e^p - 1)/e^p$, $I_n = (1 - I_f e^p)/e^p$.

of pecuniary returns that do not increase the utility of others either directly or indirectly through increased production. If the bribes of urban households yield more influence than those of rural households, then a possible outcome is for rural households to be taxed ($P_a < 1$), for urban households to receive a net subsidy ($P_n > 1$), and for the government to incur a negative trade balance ($R < 0$), implying claims on the income of next period households. And, as in the case of the Dominican Republic, it will cause a decline in foreign exchange earnings and mounting foreign indebtness.

If endowments and bribes were replaced by production activities and resources, then the withdrawal of resources from production to DUP activities would decrease production possibilities in the current period and increase claims on the incomes of next period households. Depending on the specification of the influence functions, the DUP activities (bribes) of urban households can increase the profitability of countervailing DUP activities of rural households.[15] Hence, an environment that induces the seeking of differential advantage of one group can indirectly induce DUP activities by another group whose welfare is affected by the activities of the former group.

Countries that pursue inward-oriented strategies contain elaborate administrative systems for resource allocation. These systems, often characterized by state-owned enterprises, include quantitative restrictions on imports and exports, licensing of investment in typically import substitution activities, controls on foreign investment, and numerous other instruments to influence incentives (tariffs, taxes, and subsidies). An implication of the theory on DUP activities is that the mere presence of these elaborate structures can be expected to generate more resource wastage than would be expected from an outward-oriented strategy. It would also seem that these arguments might be extended to explain, in part, the formation of state-owned enterprises (such as INESPRE and CEA in the Dominican Republic) that permit the capturing of rents by directors and employees of the enterprise.

Inducing a liberalization of interventions in an economy confronts the activities of groups seeking their differential advantage. For liberalization schemes to be successful, they need to be carried out without creating a differential advantage to some groups. The more extensive the extent and scope of intervention, the more difficult this task is likely to become. Corbo and others suggest this result when they attribute part of the failure of liberalization in the southern cone to "authorities probably faced deeply entrenched political interest groups and recalcitrant expectations."

The liberalization of interventions in an economy is likely to be more difficult the longer the distortions have been in place. Distortions in an economy that have been in place for a considerable period of time induce structural changes so that the value of protection gets built into the value of sector specific assets. An example is import competing plants and equipment that process commodities or fabricate goods that in the absence of protection lose part of their value, the loss being greater the more difficult it is to transfer the capital to other enterprises. Another example is the human capital employed in import-competing sectors that would be replaced with the loss of seniority rights and perhaps the need to undergo retraining to obtain equivalent wage levels in other activities. Hence, liberalization in the short run almost surely causes adverse wealth effects to some groups that are in direct proportion to the length of time the distortions have been in place.

Some households may not have been previously involved in DUP activities, but are simply responding to market signals (even though they may be distorted). In the presence of threatened liberalization and adverse wealth effects, they may become strong opponents to change. The end result could well be that threatened liberalization, as in the case of the

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[15]The implication is that the cross-second partial derivative is positive.

Dominican Republic, gives rise to an increase in DUP activities so that a financial crisis is required before governments can carry out policy reforms.

Perhaps, interventions and the DUP activities they generate are simply the result of policy mistakes in many countries. In practice, government planning-policy implementing processes, even when directed toward sources of market failure, are complex with a multiplicity of policy instruments and a maze of programs and projects. The development planning literature of Agarwala has documented the experiences of many countries where the mismanagement of complex processes and the development of plans based on faulty causes and effects and program-project implementation assumptions have given rise to realizations that bore little resemblance to outcomes anticipated when the plans were first initiated. Since physical and administrative infrastructures are poorly developed in many developing countries, it is difficult to target interventions that have minimal market distortion effects.

The process of liberalization is likely to be complex and difficult because of the conditions under which distortions have been generated. In many countries, liberalization may only come about when circumstances do not allow for a choice. Governments who bias their trade and development patterns to accommodate rent-seeking behavior tend to generate government budget deficits, which have to be financed either domestically or internationally. When financial crisis occurs, such as the world debt crisis of the eighties, these deficits can no longer be financed. The choices under such circumstances are very limited and policy liberalization tends to become a financial necessity rather than a luxury.

Summary and Conclusions

This paper focused on the nature of government interventions in the trade and development process. A basis was presented to explain why such interventions are generated and maintained even after it is apparent that interventions are inducing distortions that are socially wasteful. The policies pursued by inward-oriented and other selected countries were used to illustrate the policy instruments these governments commonly employ and the effects these interventions have on trade and economic growth. A case study of the Dominican Republic was used to provide more indepth insights into the magnitude and impact of distortions.

It appears that for inward-oriented countries interventions often result in overvalued real exchange rates, low and frequently negative real interest rates, and tariff and quota restrictions that tend to protect the domestic import-competing sector. Along with these interventions are interventions in domestic agricultural markets by state-owned enterprises and marketing boards who play key roles in determining agricultural input and output prices. These interventions appear to be contributing factors to central government budget deficits and to discourage public investments in areas of market failure.

The broader theories of Bates and Olson were highlighted for the insights they provide into the motivation for government intervention. The discussion on rent-seeking households was used as a basis for developing a formal model of government behavior. This approach postures that interventions are the outcome of competing interest groups seeking to achieve outcomes that are favorable to themselves but outcomes that can be socially wasteful.

Key implications are: In the early stages of development, the interests of urban consumers and import-competing industrialists coincide so that interventions tend to tax agriculture relative to the urban-industrial sector of an economy. In seeking differential advantage, an economy composed of narrow-based coalitions tends to seek interventions that are more wasteful of society's resources than are broader based coalitions. Also, narrow-based coalitions tend to slow the adjustment of interventions to changes in an economy's environment because of the time required to negotiate and to re-establish acceptable terms of

intervention. If the key to economic growth lies in society's management of market failure and investment in areas where the market failure induces underinvestment, then rent-seeking behavior interfers with this process. Rent-seeking behavior can be triggered by errors or failures of the policymaking process, which inadvertently provides some groups with a differential advantage relative to other groups. The longer distortions are in place, the more likely that sector-specific resources will reflect the value of these distortions. Thus, attempts to liberalize may encounter resistance from previously apolitical groups who face the possibility of loss in wealth.

The removal of interventions will almost surely require a comprehensive plan that deals with the sources of resistance discussed in the previous section. The time period required to carryout the plan will depend on the degree of distortions and the political importance of the enterprises that owe their existence to them. Substantial effort will be required to convince those who face adjustment costs of the longrun social benefits of discontinuing these policies.

A plan will need to address the following issues (1) the design of programs and projects that are socially profitable in areas where markets function poorly, (2) the development of an equitable means of privatizing public enterprises and, with natural monopolies, finding forms of organization that give rise to least cost operations and pricing behavior, (3) the development of socially least cost forms of public revenue generation as a substitute for instruments that give rise to distortions, and (4) the design of policies to ameliorate adjustment costs faced by low-income household.

REFERENCES

(1) Agarwala, Romgopal. Planning in Developing Countries: Lessons of Experience. IBRD Staff Working Paper No. 576. 1983.

(2) Anderson, Kym. Economic Growth and Distorted Agricultutral Incentives. Department of Economics, Univ. of Adelaide, Adelaide, S.A. Feb. 1985.

(3) _____. "Growth of Agricultural Protection in East Asia," Food Policy. Butterworth and Co., Pub., Nov. 1983, pp. 327-336.

(4) Balassa, Bela. "Policy Responses to Exogenous Shocks in Developing Countries," American Economic Review Vol. 76, 1986, pp. 244-248.

(5) Bates, Robert H. "Governments and Agricultural Markets in Africa," The Role of Markets in the World Food Economy. Eds. Johnson, D. Gale and G. Edward Schuh. Westview Press, 1983.

(6) Bautista, Romeo M. Effects of Trade and Exchange Rate Policies on Export Production Incentives in Agriculture: The Philippines. Working paper, IFPRI, 1985.

(7) Bhagwati, N. Jagdish. "Directly Unproductive, Profit-seeking (DUP) Activities," Journal of Political Economy. Vol. 90, 1980, pp. 988-1002.

(8) Buchanan, J. M. "Rent Seeking and Profit Seeking," Toward a Theory of Rent Seeking Society. Eds. J. M. Buchanan, R.D. Tollison, and G. Tullock. Texas A & M Univ. Press, 1980.

(9) Cavallo, Domongo, F. J. Cottani, and M. S. Khan. Real Exchange Rate Behavior and Economic Performance in LDC's. IBRD, 1985.

(10) Colander, David C. Neoclassical Political Economy: The Analysis of Rent-seeking and DUP Activities. Ballinger Pub. Co., 1984.

(11) Corbo, Vittorio, Jaime de Melo, and James Tybout. "What Went Wrong with the Recent Reforms in the Southern Cone," Economic Development and Cultural Change. Vol. 34, 1986, pp. 607-640.

(12) Gerrard, Christopher D., and Terry Roe. "Government Intervention in Food Grain Markets: An Econometric Study of Tanzania," Journal of Development Economics. Vol. 12, 1983, pp. 109-132.

(13) Greene, Duty, and Terry Roe. A Comparative Study of the Political Economy of Agricultural Pricing Policies in the Dominican Republic: Part III, The Effects of Price Interventions. Preliminary Draft, Department of Agricultural and Applied Economics, Sept. 1986.

(14) Hayami, Yujiro, and Vernon W. Ruttan. Agricultural Development: An International Perspective. 2nd edition. New York: Johns Hopkins Univ. Press, 1985.

(15) Honma, M., and Y. Hayami. "Structure of Agricultural Protection in Industrial Countries." Faculty of Economics, Tokyo Metropolitan Univ., mimeo, Sept. 1984.

(16) International Monetary Fund. World Economic Outlook. Washington, DC, April 1986.

(17) _____. Trade Policy Issues and Development. Occasional Paper 38. Washington, DC, July 1985.

(18) Krueger, Anne. Exchange Rate Determination, Cambridge, England: Cambridge University Press, 1984.

(19) Krueger, Anne. "The Political Economy of the Rent-Seeking Society," American Econmic Review. Vol. 64, 1974, pp. 291-303.

(20) Lofchie, M. F. "Agrarian Crisis and Economic Liberalization in Tanzania," Journal of Econmic Literature. Vol. XXII, 1984, pp. 531-571.

(21) Lucas, R. E. "On the Mechanics of Economic Development." Univ. of Chicago, mimeo., 1986.

(22) Orden, David, Duty Greene, Terry Roe, and G. Edward Schuh. Policies Affecting the Food and Agricultural Sector in Peru, 1970-1982: An Evaluation and Recommendations. Report prepared for USAID by Department of Agricultural and Applied Economics, Dec. 1982.

(23) Pitt, Mark M. "Alternative Trade Strategies and Employment: Indonesia," Trade an Development in Developing Countries. Eds. A. O. Krueger, H. B. Larry, T. Monson, and N. Akasanee. Vol. 1. Chicago Univ. Press, 1981.

(24) Pryor, Frederic L. "Chapter 11: Rent-Seeking, the Growth and Fluctuations of Nations: Empirical Tests of Some Recent Hypotheses," Neoclassical Political Economy: The Analysis of Rent-seeking and DUP Activities. Ed. David C. Colander. Ballinger Publishing Co. 1984.

(25) _____. "Chapter 5: A Quasi-test of Olson's Hypotheses," The Political Economy of Growth. Ed. Dennis C. Muller. Yale University Press, 1983.

(26) Roe, Terry. "Agricultural Policy in Developing Countries: The Transfer of Resources From Agriculture." Paper presented at the Conference on Food Policy and Politics: A Perspective on Agricultural Development, Purdue University, May 11-13, 1986.

(27) _____, and Duty Greene. The Estimation of a Shadow Equilibrium Exchange Rate: A Direct Method. Staff Paper P86-45. Department of Agricultural and Applied Economics, University of Minnesota, Oct. 1986.

(28) _____, Mathew Shane, and De Huu Vo. Price Responsiveness of World Grain Markets: The Influence of Government Intervention on Import Price Elasticity. TB-1720. Econ. Res. Serv., U.S. Dept. Agr., June 1986.

(29) Short, Peter. Appraising the Role of Public Enterprises: An International Comparison. IMF Occasional Paper Series. Washington, DC, 1983.

(30) Scobie, Grant M. Food Subsidies in Egypt: Their Impact on Foreign Exchange and Trade. Research Report 40. IFPRI, Aug. 1983.

(31) Tanzi, Vito. "Fiscal Disequilibrium in Developing Countries," World Development, Vol. 12, 1982, pp. 1069-1082.

(32) U. S. Agency for International Development. "Agricultural Prices and Policies in Egypt (1974-1981)," Country Development Strategy Statement. Feb. 1985.

(33) U. S. Department of Agriculture, Economic Research Service. Food Policies in Developing Countries, FAER-194, Dec. 1983.

(34) World Bank. The World Development Report, 1985. Washington, DC.

(35) Yen, Tze-yi, and Terry Roe. Determinants of Rural and Urban Household Demand: An Analysis of Dominican Household Consumption. Economic Development Center Bulletin No. 86-3. Department of Agricultural and Applied Economics, July 1986.

TECHNOLOGICAL POTENTIAL FOR INCREASING CROP PRODUCTIVITY IN DEVELOPING COUNTRIES

Robert Herdt[1]

The potential for increasing food production can conveniently be considered for the short, medium, and long run. In the short run, increased food production can only come from fuller use of existing technologies. Wide spread use of known technologies occurs in response to changing incentives that make them more attractive, by increasing farmers' knowledge of the technologies and by assuring adequate supplies of inputs to be used as part of the technologies to increase production. All these changes require political and economic policy changes that may be forthcoming with a demonstration of great unexploited technical potential for increased production.

In the medium run, adaptive research to change production technology and investments to change the environment to make existing technologies more attractive is the principal source for increasing production. Adaptive research may include technology transfer, although the potential for direct transfer across agricultural ecologies is limited.

In the long run, advances in basic science and its applications to agricultural production many be the major factor determining rates of output increase. The theoretical possibilities offered by recombinant DNA and other biotechnology techniques appear to be very large, but until there has been more experience with such technologies there is little one can say about their potential in the developing world. Of course, if these technologies are not applied to agricultural production problems of developing countries, production cannot improve and retrogression may occur in these countries. These possibilities have prompted the Rockefeller Foundation to support a program of biotechnology research on rice, a crop of immense importance for the developing world. That program is a vehicle for training researchers from the developing world in the techniques of biotechnology. This paper will, however, concentrate on the short- and medium-run potential and not discuss the possibilities or potential problems raised by biotechnology.

Will Proven High Productivity Technology Spread Further?

Existing high productivity technology can contribute to further increased production if its use is extended to new areas. What is the potential for further spread of semidwarf wheat and rice technology?

Dalrymple has monitored the spread of semidwarf varieties in a series of publications that show rates of adoption of semidwarf wheat and rice for principal producing countries in the developing world (7,8,9).[2] By 1982-83, semidwarf varieties had spread to about 50 percent of the wheat and rice areas, leaving an apparent ample scope for further spread. However, examination of their spread across countries shows that their rate of spread has slowed (figs. 1-2). Analysis of semidwarf rice varieties in India shows that in major producing states (such as Andhra Pradesh and Tamill Nadu) adoption reached its plateau by the midseventies. In the eastern states (Orissa, Bihar, and West Bengal) adoption was slow but picked up in the midseventies, and in other states adoption had slowed by the late seventies (fig. 3). Adoption, measured as a proportion of rice area, is high in some states (Punjab and Haryana) and very low in others, especially in eastern India. Concentration was initially associated with

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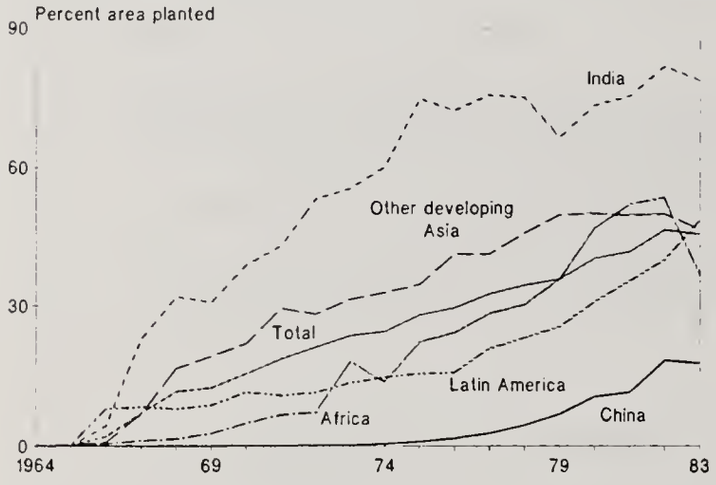
[1]The author is a senior economist, The Rockefeller Foundation, New York.

[2]Underscored numbers in parentheses are listed in the References at the end of the article.

Figure 1

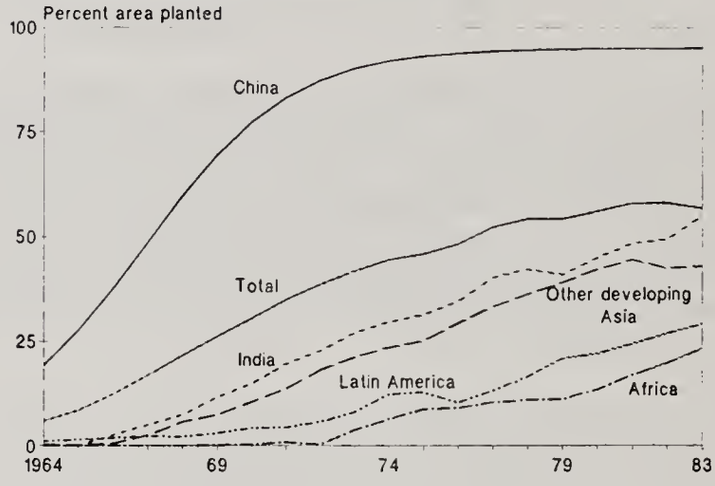
Adoption of semidwarf wheat varieties in major developing countries and regions



1/ Source: (7, 8).

Figure 2

Adoption of semidwarf rice varieties in major developing countries and regions



1/ Source: (7, 8).

irrigation, and, when most of the irrigated area was planted to the semidwarfs, the rate of spread slowed considerably (20,33). Walker and Singh argued that high-yielding varieties of sorghum and millet have reached a plateau of adoption in India (45). Thus, while there is still some scope for further spread of semidwarf varieties, it is unlikely to be rapid, and, because they will spread onto nonirrigated or newly irrigated land, the associated productivity gains on the new areas will be considerably lower than on the initial adoption areas.

Intensification

What scope exists for further intensification of production practices where semidwarf varieties are now grown? This could be answered with good production function estimates that separate the effects of fertilizer, irrigation, and variety. Because varieties, fertilizers, and irrigation are complementary, they are used together by farmers and so multicollinearity makes estimating the production function from farm surveys extremely difficult and yields unreliable results. For that reason, I developed an analysis that uses a land-quality based approach to analyze the contribution of each input in the case of semidwarf rice (20).

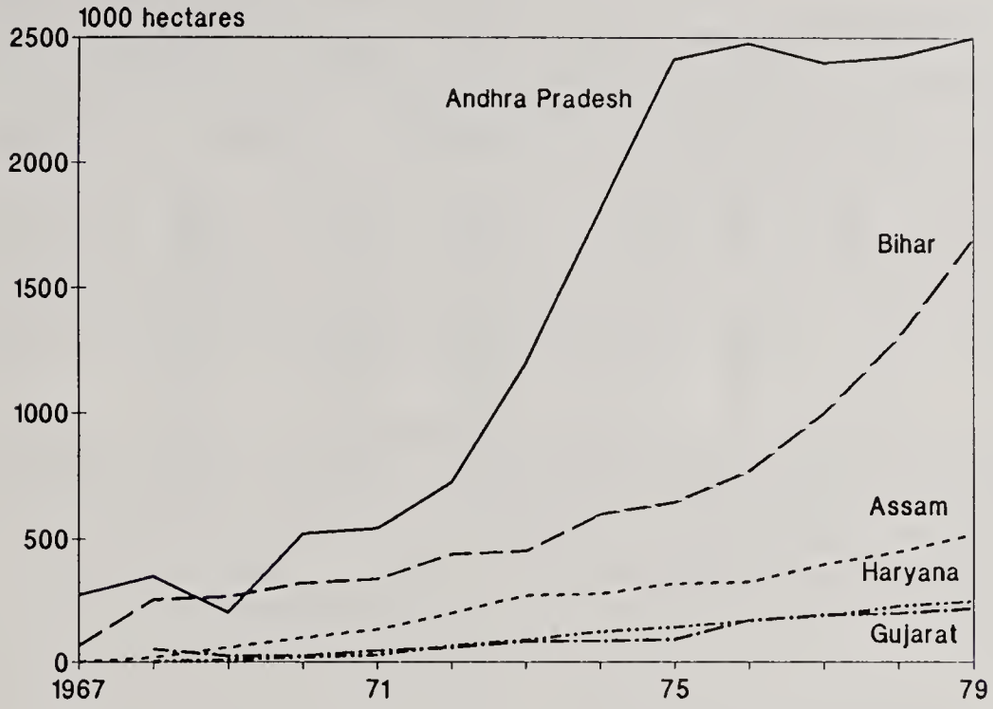
This model has been used to ask what is likely to happen with increases in fertilizer availability, with more rapid spread of irrigation, with changes in the supply of fertilizer or rice prices, and similar questions. A complete discussion of the model and results of its application is beyond the scope of this paper, but a few highlights are useful.[3]

The model distinguishes five different production technologies by irrigation and variety type. The use of fertilizer is closely associated with the use of modern rice varieties, which, in turn, are closely associated with the availability of irrigation. Some rainfed areas are planted

[3]Further details are available in Barker and Herdt (2, p. 18).

Figure 3

Adoption of semidwarf (HYV) rice varieties in states of India



to semidwarfs, but they are mainly grown with irrigation and are expected to spread slowly to rainfed areas. The model shows that if, between 1980 and 2000, irrigated areas grow at the historical rate new planted, modern rice varieties will continue to spread at a rate similar to the historical pattern and ferilizer availability will grow at 5 percent per year. The use of modern technology will reach the levels indicated in table 1, with an output of 409 million tons. Individual models were developed for eight countries that produce 85 percent of Asia's rice.

The adequacy of this level of production can be judged only by comparing it with the projected level of demand. Demand was projected using income and population growth rates and income elasticities shown in table 2. Most projection exercises assumed that any shortfall between future demand and production will be covered by imported rice, but our model incorporates the price elasticities of demand, thereby permitting a determination of the price implications of alternative import policies.

Table 1 shows that with the base run supply projection only Thailand will export in the year 2000, when net imports for the eight countries are projected to reach 35.4 million tons in order to hold real prices constant. If self-sufficiency (zero imports) is imposed, rice prices are projected to be nearly double their 1980 levels by 2000 and per capita consumption is projected to fall from its 1980 level of 135 kilograms (kg) per capita to 126 kg per capita.

Under these projections, most countries will reach, with present technology, rather high levels of fertilizer application, and modern varieties will have spread about as widely as one could expect, given each country's irrigation capacity.

The data appears to indicate considerable scope for the extension of irrigation, especially in Thailand, Burma, and Bangladesh, as well as in a number of other countries where only half to two-thirds of the rice area is projected to be irrigated in the year 2000. However, irrigation is expensive, and its construction is also constrained by the capacity to mobilize the necessary human and physical capital resources in most countries. It is my view that it is highly unlikely that irrigated area can grow significantly faster than is reflected in table 1, but to

Table 1--Base run projections of rice production, consumption and prices for selected Asian countries for the year 2000.

Country	Production Fertilizer 1/	Area		With zero imports		With imports to hold price at 1980 level	
		MVA	Irrigation	Price	Consumption	Consumption	Imports 2/
	Mil. mt	Kg/ha	Percent	1980=100		Kg/capita	Mil. mt
China	196.1	148	3/ 65	94	113	109	116	6.0
India	99.4	67	68	51	210	69	89	13.0
Indonesia	34.1	89	74	84	380	112	204	8.5
Bangladesh	28.7	32	63	24	171	144	188	5.4
Thailand	23.8	25	18	41	4/ 100	4/ 201	201	-.3
Burma	14.7	71	5/ 56	21	127	178	195	.6
Philippines	9.6	61	89	42	225	82	114	1.7
Sri Lanka	3.1	102	73	66	207	99	141	.5
Total or average	408.8	75	64	54	192	126	156	35.4

1/ Rought rice.
2/ Milled rice; negative sign indicates exports.
3/ Hybrid rice.
4/ Exporting nation, assumed to continue exports.
5/ Includes modern and "improved" varieties; the balance are traditional varieties.

Source: (20)

Table 2--Annual growth rates of population and income, and elasticities of demand with respect to income and prices used in the rice projections model.

Country	Projected growth rate of--		Elasticity	
	Population 1/	Income per capita	Income	Price
China	1.2	2.0	0.45	-0.50
India	1.8	2.0	.45	-.50
Indonesia	1.5	5.0	1/ .50	-.60
Bangladesh	2.5	2.0	.45	-.50
Thailand	2.3	5.0	.05	-.30
Burma	2.4	2.0	.30	-.40
Philippines	2.7	3.5	.25	-.40
Sri Lanka	2.3	2.0	.40	-.60

1/ Value for 1980-85. Because of the rapid growth of per capita income, the income elasticity was assumed to decline by 0.1 ever subsequent 5-year period.

Source: (20).

determine the potential effect of greater investments in irrigation, a rapid growth scenario was developed in which it was assumed that irrigated rice area grew at twice the rate of the historical period.

That scenario shows significant difference in the percentage of area irrigated in the year 2000 in countries where irrigation increased rapidly since 1960, but where irrigation either spread slowly or where a very large proportion of the rice area was irrigated in 1980 there was little difference. Average irrigated area for the eight countries would reach 62 percent compared with 54 percent in the base run situation, and modern varieties would reach 72 percent of the total rice area. Under this scenario, rice production is projected to reach 466 million tons, net imports would reach only 13.6 million tons, and, Thailand, Burma and Sri Lanka would export rice if prices are held at 1980 level. If imports are constrained to zero, rice prices

would increase by only 30 percent, and per capita consumption of rice would increase to 144 kg.

Obviously, output growth dependent on irrigation investment comes at a cost to the economies involved. Food imports are also costly and require recurring annual foreign exchange costs. The fast rate of output growth requires substantially higher irrigation investments than the base run, but because of the extra output produced, food import costs are lower in subsequent years. This effect is illustrated in table 3. It was estimated that in 1985 annual expenditures of $5 billion would be required to hold real rice prices constant following the base run scenario. The fast output growth scenario, which produces net exports in 1985, has a lower net cost, although its irrigation investment cost is almost twice that of the base run. By the year 2000, annual expenditures of $16 billion are required even in the fast output scenario, with about one third required for imports. The base run scenario requires annual expenditures of $20 billion, with most of that going for rice imports.

It appears that increases in the productivity of fertilizer and irrigation are necessary if developing countries are to meet their needs for rice through the year 2000. An indicative projection assuming such increases in productivity was made to determine how great a productivity gain would be adequate. To illustrate the type of assumption, the production function for irrigation semidwarf varieties in the base model for the Philippines reaches a maximum of 2.9 tons per hectare (ha) at 105 kg of fertilizer nutrients in the basic model. In the enhanced productivity indicative projection, it reached a maximum of 4.4 tons per ha at 128 kg of fertilizer nutrients in the year 2000. This productivity is within the potential of genetic material now available but is not being reached on average across all rice farms in the Philippines. To raise the average productivity to that level, I believe it will be necessary to either produce better varieties or teach farmers how to better exploit the existing ones--both require continued investment. An increase in productivity would enable the Philippines to keep up with demand through 2000; comparable increases in productivity would enable other countries to do likewise.

This analysis convinces me that there is little significant "unused potential" in current rice technology and that continued improvements in technology as well as increased fertilizer use and irrigation investments will be needed to produce enough rice to adequately feed Asians over the coming several decades. Similar studies, to my knowledge, are not available for wheat, but current data indicates rapidly increasing wheat imports in the developing countries (4). However, it is difficult to determine the potential for further intensification of wheat production without a detailed anaylsis. An alternative is to examine the demonstrated level of potential yields.

Table 3--Annual expenditures associated with two alternative scenarios of the future rice situation in eight Aisan countries 1/

Year	Base run scenario				Fast output scenario			
	Irrigation	Fertilizer	Net imports	Total	Irrigation	Fertilizer	Net imports	Total
	Million US$							
1985	1,741	1,410	1,903	5,054	3,224	1,500	-270	4,454
1990	1,815	1,720	6,195	9,730	3,458	1,906	1,755	7,119
1995	1,917	2,030	10,955	14,902	5,954	2,272	4,515	12,741
2000	2,051	2,407	15,972	20,430	7,199	2,818	6,000	16,017

1/ Irrigation costs are annual investment costs; fertilizer costs are the value of fertilizer used in rice production at a price of US$225 per metric ton of area; import costs are calculated by assuming a price of US$300 per metric ton of milled rice.

Raising Farmers' Yields to Their Maximum Potential

Some analysts have approached the issue of potential food production by determining the biomass production capacity of green plants and by determining food production by adjusting for nonconsumable portions (46). This approach may be suitable for determining some ultimate food production potential, but it is not appropriate for a 20-to-40 year projection period. There also is literature reporting production functions based on farm survey data, but because they are based on farmers' practices, they cannot be used to reflect potentials that exceed those levels. Only experimental data can provide an acceptable reflection of potential productivity that is demonstrated but not yet applied.

Factors that Contribute to Crop Yield

Crop variety, fertilizer nutrient level, pest control, and water availability are all important factors. Planting date, soil chemical characteristics, drainage, and weather conditions at harvest are less often mentioned but are also important. Economists seldom recognize the effects of solar radiation and temperature, but to crop physiologists, they are the overriding factors determining potential yields. Thus, depending on what factors are controlled at what levels, one may define or observe a number of differnt yield levels that may be thought of as "the maximum potential." Therefore, some definitions are necessary.

For convenience in defining these concepts, the terms "experiment stations," "onfarm trials" and "farmers' fields" are used. Each is understood to be representative of such conditions in the region of interest. "Environmental conditions" and "management factors" are used to mean roughly noncontrollable and controllable factors. Roughly is used because given enough money one can control all the factors necessary to grow bananas at the earth's poles! Experiment stations are observed to have invested more than most farmers in controlling environmental factors, and while there is a continuum between farmers' fields and experiment stations, there is an observable difference between the typical farm and the typical experiment station, which is important for this discussion.

Researchers must choose levels for all controllable factors when running yield experiments. When the objective is to obtain maximum yields, it is natural to try and set all factors at nonconstraining levels. But such experiments may not reflect "realistic" potentials for farmers. Table 4 presents a classification of the various measures of potential yields. Sunlight and the innate capacity of the plant are constraining in all such experiments. "Noncontrollable" environmental factors may be modified in a laboratory but not in experimental fields. Test factors are varied within an experiment, nontest factors are held constant, but both are controllable. Other related factors are all other things, usually environmental, that can only be controlled at a cost. The highest yields are generally measured when fewest factors are constraining; hence, it is important to recognize which definition of potential yield is being used.

The physiological potential is defined here as the maximum photosynthetic capacity of a plant to produce dry matter, unconstrained by pests, nutrients, water, or any other production constraint. "Swaminathan stated "It is, in a way, the most optimistic estimate of crop yield based on present knowledge and available biological materials under ideal management in an optimum physical environment" (41). The physiological potential is basically dependent on the level of solar radiation and the innate photosynthetic efficiency of the particular plant (48). Because it is impossible to control all factors in field production, this is essentially a theoretical yield, not observable except perhaps under the most restrictive greenhouse conditions.

The experiment station maximum yield is a somewhat less restrictive concept and is defined so as to be observable. It is the yield produced under experiment station conditions where "all" controllable factors are held at their maximum yield level. Even this concept entails some

Table 4--Factors that constrain yields in major types of agri. experiments used to measure potential yields

Contraining factor	Definition of potential yields						
	Maximum physiologic potential	Experiment station			Onfarm trials		
		Maximum	Optimum input	Theoretical optimum	Maximum	Theoretical optimum	Optimum input
Sunlight, plant capacity	CF	CF	CF	CF	CF	CF	CF
Noncontrollable environment	CF	CF	CF	CF	CF	CF	CF
Test factors (controllable)			EV	EV	EV	EV	EV
Nontest factors (controllable)				TO		TO	CF
Other related factors					CF	CF	CF
Are yields observable or theoretical?	T	O	O	T	O	T	O

CF = Contraining, that is researcher cannot or has not changed to nonconstraining level.
Blank = Factor has been modified by researcher to a nonconstraining level.
EV = Factor is varied in the experiment.
TO = Assumed to be at its theoretical economic optimum.
O = Observable
T = Theoretical.

difficulties. Yields vary from replication to replication, season to season, and year to year simply because of the variability in soils and crop production conditions. A good quantitative estimate of the experiment station potential yield, therefore, should be obtained as an average of a number of maximum yield experiments.

It is possible to compute experiment station optimum input yields for two or three principle manageable inputs. These are the yields obtained when inputs are applied to their economically optimal levels. Sometimes a comprehensive production function can be estimated, but more often a series of single-input response functions must be used because of limitations in the experimental designs used. These computed optimal yields will, in general, differ from onfarm optimum input yields because of the practice of holding nontest and other related factors at a high level in experiment station research.

The experiment station theoretical optimum yield is the yield that would be obtained if all inputs were set at their economically optimal level, given the other related factors prevailing on the experiment station and the prevailing prices of inputs and products.

This is a theoretical concept. It is generally impossible to calculate the optimal level of each input because even using very large experimental data sets and advanced computational techniques it is difficult to obtain quantitative estimates of diminishing marginal productivity for each manageable input.

Onfarm trials maximum yields can be observed from experiments in farmers' fields in which controllable inputs are held at their maximum yield levels by researchers or from maximum yield contests or demonstrations designed for the purpose. These yields will generally be lower than maximum experiment station yields because other related factors cannot be controlled in farmers' fields. Data are generally reported as averages for a number of separate trails because of the variability between sites.

Onfarm trials theoretical optimum yields can be defined in a similar way as the experiment station theoretical optimums, but from farmers fields experiments. As with experiment station theoretical optima, these are impossible to either observe or compute because it is practically impossible to obtain estimates of multiple input production functions in which all inputs show diminishing marginal returns (21,37).

Onfarm trials optimum input yields are defined as the yields obtained when the test factors are set at their economically optimal level, but nontest factors and other related factors are at farmers' levels. Such onfarm optimum input yields cannot be directly observed but may be computed from appropriate estimates of the response functions for several test inputs.

Farmers' yields in onfarm trials are the reseachers' attempt to simulate farmers' actual practices under their environmental conditions but within an experiment so input levels and yields can be accurately measured. This will provide an accurate indication of yields on the sample of farms where the experiments are conducted, but may not be representative of a wider population of farmers.

Average yields are the level reported in official statistics for a country, province, or region for which such statistics are estimated. They may differ from the farmers' yields in onfarm trials because of differences in measurement techniques (crop-cut versus estimate) and differences in geographic coverage.

An economically recoverable yield gap is the difference between average yields and farmers' fields theoretical optimum yields for a given place. It cannot be observed except in very special circumstances because farmers' optimal yields cannot generally be observed. Instead, various approximations are used, depending on the availability of data.

It is clear that for an economically recoverable yield gap to exist, the difference between farmers' yields in onfarm trials and maximum yields in onfarm trials must be relatively large to allow for the difference between maximum yield input levels and economically optimal input levels. The difference increases as environmental constraints, complexity of cropping systems, costs for credit, risk allowances, and marketing costs increase.

Yield Gaps in U.S. Agriculture

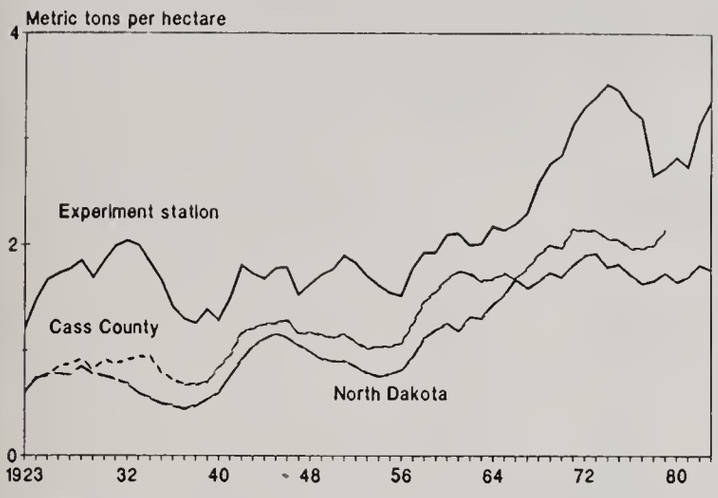
It is normal to observe a substantial difference in yield between experiment station and average yields. Data from the United States illustrate the point. Figures 4-5 shows North Dakota experiment station, and Cass County average wheat yields during 1923-83 (14). For the 1923-32 decade, experiment station's yields were 112 percent higher than the county's average yields; for 1943-52, they were 49 percent higher; and during 1967-76, they were 55 percent higher. The experiment station yields during 1923-83 were on average 64 percent higher than the county yields and 98 percent higher than North Dakota yields. Average farm yields increased 112 percent from the 1923-28 period to the 1973-78 period, while experiment station yields increased 66 percent. In the early sixties, corn yields averaged 1.5 tons per ha, while experiment station yields were nearly 4 tons per ha. By the early eighties, State yields had increased to 4 tons per ha, while station yields were 7 to 8 tons per ha.

A comparison for soybeans shows a similar phenomena (fig. 6). These data match results from 63 experiment stations with the average yields in the counties in which they were located (38). In 1943-47, the experiment station yields were 73 percent higher than the county averages. For 1959-63, they were 69 percent higher, and for 1975-79, they were almost the same percentage higher. Average yields increased about 40 percent over the period, and average experiment station yields increased 35 percent.

In Illinois, the Morrow plots have demonstrated, for more than 100 years, the effect of different soil management treatments on corn and other crop yields. While not strictly a maximum yield experiment, various treatments have been designed to demonstrate high yields and provide a basis for our comparison (43). The Allerton Trust Farms in Piatt County were deeded to the University of Illinois in 1946. They are not experimental but "are managed to produce maximum income to support the operation and maintenance of the Robert H. Allerton Park and Conference Center" (42).

Figure 4

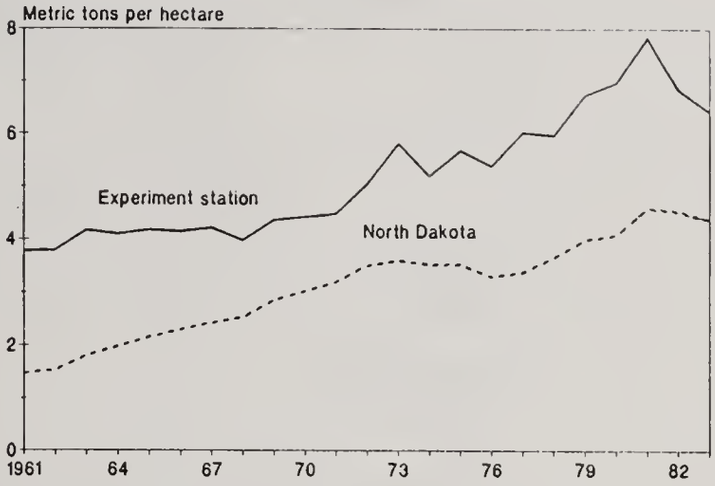
Average farm yields, 5-year averages, North Dakota wheat



Sources: (14, 30, 44).

Figure 5

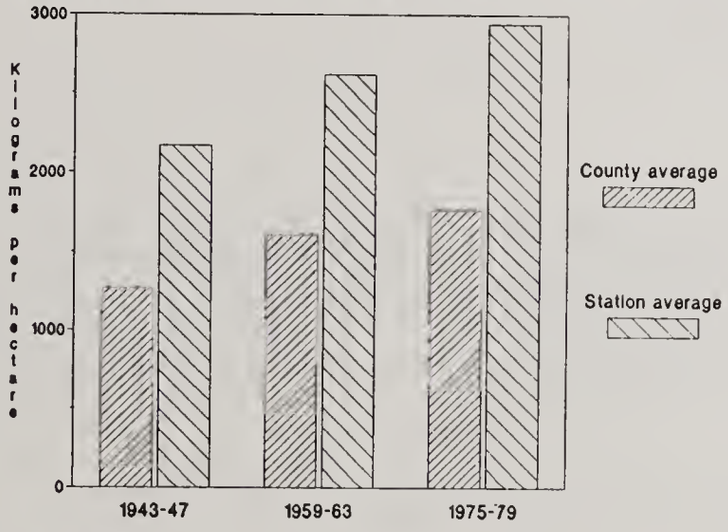
Average farm yields, 5-year averages, North Dakota corn



Sources: (14, 30, 44).

Figure 6

Average county and experiment station yields of soybeans from 63 locations, United States



Source: (38).

A comparison of Morrow, Allerton, Piatt County, and State average yields is shown in table 5. Morrow plot yields remained substantially above Allerton farm and county averages over the entire period, even though there was some variation (table 5). In the seventies, county average yields approached Allerton farm yields, but experiment station yields maintained an advantage over both. Allerton corn yields increased 54 percent from 1950-55 to 127 bushels per acre (8.0 tons per ha) in 1972-76, soybean yields increased by 22 percent to 37.8 bushels per acre (2.5 tons per ha); county average yields for the two crops increased by about the same proportion.

Table 5--Experiment station, university farm, county, and State average corn and soybean yields, Illinois

Commodity and year	Experiment station (Morrow plots)1/	Allerton Trust Farm	Piatt County	State average
	Metric tons per ha			
Corn yields:				
1955-59	6.7	5.4	4.8	4.1
1965-69	9.4	6.3	5.3	5.8
1972-76	9.4	8.0	8.0	6.4
Soybean yields:				
1966-70	3.8	2.7	2.4	2.1
1972-76	2.9	2.5	2.4	2.1

1/ Yields from plot 4, MLP + LNPK treatment, a rotation of corn-oats from 1955 to 1966 and corn-soybeans from 1967 to the present. Each point is the average of 3 years of observations rather than 5 because corn was alternated with the other crop on this plot.

Sources: (42, 43).

The long continuation of a yield gap in several U. S. situations illustrates that this is a normal situation and cannot be taken as a priori evidence of exploitable technology. The dramatic difference in the gap between experimental and county average yields, on the one hand, and maximum profit and county average yields, on the other, also suggests that one should look carefully at experiment station yields before implying that they reflect yields that could be economical.

Potential Yields of Principal Developing Country Crops

Semidwarf rice and wheat varieties were the basis for the "green revolution" that many observers reported about in the late sixties and seventies. Maize, sorghum, and millets have not seen nearly as many widespread technical changes in the developing countries.

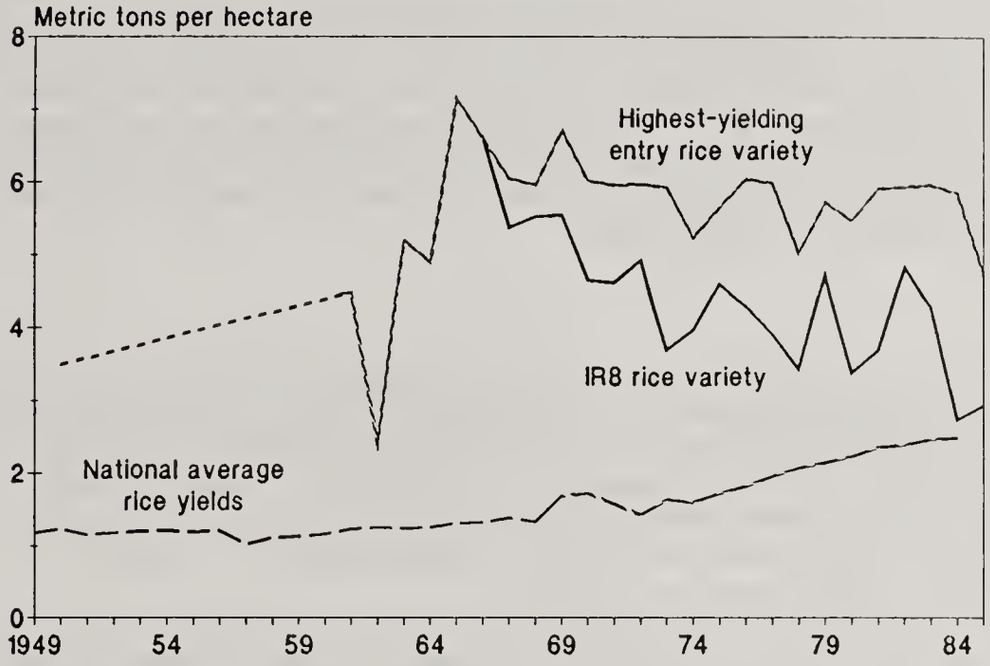
Rice

The first semidrawf rice varieties (IR8 and TN1) released to developing country farmers in 1965 had their shortcomings, but they were extremely high yielding as long as insects and diseases were absent. When such pests attacked them, they quickly succumbed. A series of newer, much more insect and disease resistant varieties have been produced by International Rice Research Institute (IRRI) and the rice research programs of the Asian countries since 1965. One of these, IR36, was estimated to have been planted to 20 million ha during the early eighties, but newer varieties had largely, but not completely, displaced it by 1985. Even IR8 is still planted by farmers in some areas where disease and insect pressure is minimal.

Casual familiarity with these facts has led many observers to assume that the rice varieties developed in the 20 years since IR8 was released must be higher yielding than IR8. However, examination of the available data do not support that and, in fact, tend to suggest the opposite. Figure 7 shows experiment station yields of the rice varieties available in the Philippines prior to the release of IR8 and, being in 1966, average experimental yields from a

Figure 7

Potential yields on newly released rice varieties in the year of release, Philippines



Sources: (5, 15, 32).

long-term set of fertilizer response trials organized by IRRI and conducted on three widely dispersed Philippine government research stations and at IRRI (15, 23).

There was a sharp increase in the yield of the highest-yielding entry from around 5 tons per ha in 1960 to over 7 tons per ha in 1965 when IR8 was released. Thereafter, yields are shown for the approximate "experiment station optimum input" yield level of IR8 and the highest-yielding variety tested.[4] Yields of IR8 declined after 1965, and yields of the highest-yielding entry also declined, although less rapidly. They certainly did not show an increase over time.[5] This is not to suggest that the newer rice varieties do not have advantages over IR8. Their yields are much more stable in the presence of insects and diseases than IR8, and they mature in fewer days, thereby permitting intensification of land use. However, they do not have any higher yield potential than IR8.

Comparing the national average rice yields in the Philippines with the average experiment station yields makes clear how farmers have been "catching up" with the potential created by the innovation of the sixties. The same picture would emerge from a comparison of rice yields in other countries with the potential.

Experimental evidence comparing rice farmers' production practices with onfarm trials maximum yields also suggests rather modest differences. In over 450 experiments, carried out in 9 provinces of 6 Asian countries over a period of 3 years, the difference between farmers' average yields and average yield with the high-input package was 33 percent or about 0.9 tons per ha in the wet season. Of that difference, failure of farmers to apply the optimum level of fertilizer accounted for 22 percent, or about 200 kg per ha in a group of farms where

[4]Yields are averages across four stations and for wet and dry seasons at maximum yield fertilizer level for each season.

[5]An analysis of the 1966-80 data from this experiment is presented in Flynn and De Datta (15).

yields averaged about 2,700 kg per ha (19). This is quite different from the average yield gap of 900 kg per ha that was observed in the experiments, and even more dramatically different from the yield gap between the experimental yield of 6.8 tons per ha and the national level of 2.5 tons per ha in the Philippines (22).

My conclusion from this large body of data and analysis stands: "what is technically possible is more modest than what most observers admit; the economics of substantially higher yields are not attractive; the costs associated with the credit and tenure arrangements that often prevail in developing countries make higher input use totally unattractive to some farmers. Thus, the available technology is being used to its potential. If further growth is to be realized, continued development of technology must be combined with institutional reforms that make current technology attractive to users" (19).

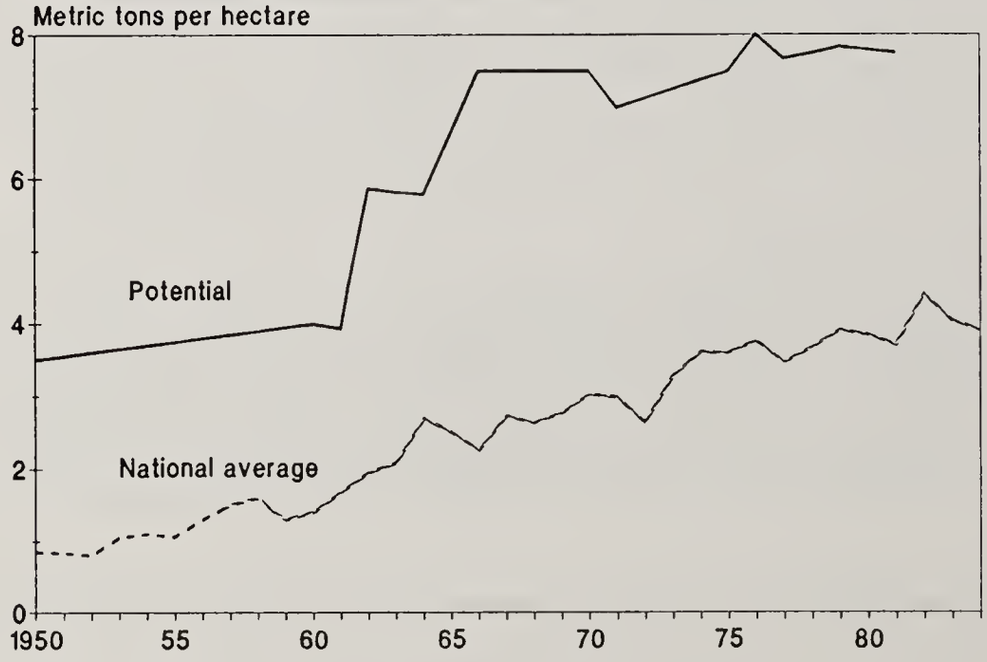
Wheat

Reported "potential" yields for semidwarf improved wheat varieties developed by CIMMYT and the Mexican agricultural research establishment and released in Mexico since the early fifties are shown in figure 8. Unlike the rice data, there is an indication that wheat yield potential has continued to increase since 1965. The increase has been rather slow, and, in recent years, modest compared with the breakthrough between 1961 and 1966. As with rice, the difference between national average yields and the potential as measured in wheat the experimental data has been eroding since the midsixties.

Some onfarm research evaluating the economically recoverable yield gap for wheat in India is summarized in table 6. There the "economic yield potential" has been calculated by taking into account the total cropping pattern (in which wheat often must be planted "late" because of other crops), the available irrigation water, and the profitable level of inputs as estimated in onfarm experiments (3). The results show that the economically recoverable yield gap is in the 0.8-1.3 tons-per-ha range, not the 3-4 tons per ha implied by a comparison of experimental and average farm yields. Still, as Byerlee and his colleagues point out, a yield gap of 1 tons per ha is worth making an effort to understand and recover.

Figure 8

Potential yields on newly released wheat varieties in the year of release, Mexico



Sources: (5, 15, 32).

Table 6--Estimated yield gap for wheat considering total productivity of cropping pattern and irrigation water availability, India

Item	Cropping region and system		
	Punjab Rice/wheat	Punjab Cotton/wheat	NWFP 1/ Maize/wheat
	Tons per hectare		
Farmers' average yield	1.8	2.2	2.8
Economic yield potential 2/	3.0	3.0-3.5	4.0
Yield gap:	1.2	.8 - 1.3	1.2
Volume		Percent	
Share	40	27-37	30

1/North West Frontier Provinces.

2/Based on results of onfarm experiments.

Source: (3).

Maize

The maize story is more complex. There was no dramatic spread of semidwarf or other "new" maize varieties in the developing world, as with wheat and rice, even though many institutions have been involved in maize and wheat research. Reasons for this difference are complex and beyond the scope of this discussion, but because the research system has been active, there is a large body of data that can be examined to determine the performance of the available technology.

Among countries in Africa, Kenya has had a rather active and successful maize research program. Figure 9 shows the potential yield of maize varieties released by the Kenyan national program for the "high ecozones" along with averages national yields (32). It is evident that considerable progress has been made since 1960 in improving the potential yields of maize varieties suitable for ecozone. Only a few varieties has been released for the "marginal" ecozones, and those have much lower potential yields. National yields, at least as reflected in Food and Agriculture Organization (FAO) data, have not increased in any perceptible way, raising the question of why. Similar lack of maize yield improvement is evident in other African countries. Many national breeding program have been producing improved maize varieties, some using maize germplasm from CIMMYT in their own breeding and others simply selecting varieties from material supplied by CIMMYT. Recent reports on the performance of CIMMYT maize germplasm consolidate results from experimental variety trials at a large number of sites in Latin America, Africa, Asia, and the Middle East.

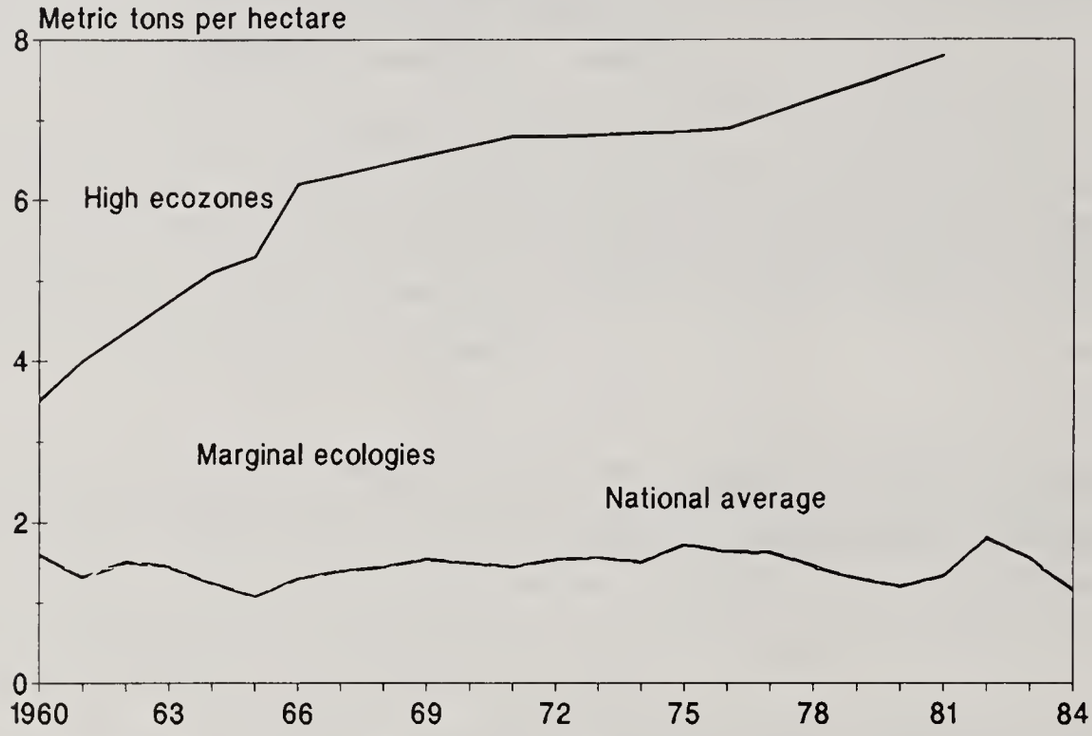
In trials conducted during 1982-84 at 94 experiment station sites in the developing countries, intermediate maturity, white CIMMYT maize yielded an average of 4.0 tons per ha. In trials at 151 sites between 1979-84, late maturity, white CIMMYT maize yielded an average of 5.0 tons per ha (34). These experimental yields are far above the average 2.0 tons per ha yield of maize in the developing world over the same period (13).

A recent paper compared the performance of CIMMYT maize with local checks in 12 countries of eastern and southern Africa, 11 countries in west Africa, and 3 countries in central Africa in experiment station trials between the midseventies and 1982 (16). The local checks were improved varieties, sometimes the widely grown hybrid SR52.

In eastern and southern Africa, the CIMMYT maize averaged 5.8 tons per ha compared with 5.2 tons per ha for the checks; in central Africa, it was 7.2 tons per ha compared with 6.2

Figure 9

Potential yields on newly released maize varieties in the year of release, Kenya



Sources: (5, 15, 32).

tons per ha for the checks; and in west Africa, it was 5.0 tons per ha compared with 4.3 tons per ha for the checks. Average maize yield for 1976-80 was 1.3 tons per ha in eastern and southern Africa, 0.7 tons per ha in central Africa, and 0.8 tons per ha in west Africa (13). Not only did the CIMMYT varieties far exceed national averages, but the local checks also exceeded national averages. There was little difference between CIMMYT maize yield potential and varieties already "available."

These data suggest there is a large yield gap between the technology presently being used by farmers and that which is available. To see how improved maize technology performs under farmers' conditions in order that this gap can be understood, research reporting of onfarm trials was examined. The available data from onfarm trials show that the gap is not nearly as dramatic as implied by the above comparisons. Unfortunately, there are relatively few usable onfarm experimental data reported in the literature, despite the upsurge of "farming systems" research. Many research results are not reported, and when they are reported, they may be published and, hence, are difficult to obtain. The data reviewed and summarized in table 7 are highly scattered samplings, and they give quite a different picture than the experiment station trials reported above.

Onfarm trials were conducted at 26 locations in Veracruz State of Mexico from 1975-80, testing local and improved varieties at farmers' and higher input levels (table 7). The farmers' and improved varieties both yielded 2.0 tons per ha at farmers' input levels. At high inputs, the improved variety yielded 3.4 tons per ha, compared with 3.1 tons per ha for the farmers' varieties.

Similar trials at 418 sites in Ghana in 1982-83 (table 7) averaged 1.8 tons per ha with local maize varieties and farmers' inputs, compared with 3.0 tons per ha for the improved variety with an intermediate level of inputs (not reported in the table) and 3.5 tons per ha for the improved variety with a high level of inputs (34). In another set of trials, 74 sites in Ghana for over 3 years, the improved varieties averaged 3.9 tons per ha and the local farmers yielded 2.8 tons per ha when fertilizer and other inputs were held constant (table 7).

In Guatemala, the yields of improved maize varieties were compared with local varieties when grown with farmers' inputs and management at 7 sites in 1976 and at 16 sites in 1977-78. The improved varieties yielded 4.0 tons per ha, compared with 2.9 tons per ha for local varieties (34). In similar trials at 24 sites in Paraguay, improved varieties yielded 3.0 tons per ha, compared to 2.7 tons per ha for the local varieties.

Onfarm trials carried out by Haiti's agricultural department in cooperation with CIMMYT for the purpose of generating appropriate maize recommendations were reported in detail by Yates and Martinez (47). The experiments, conducted in three cycles between February 1981 and the end of 1983, gave results summarized in table 7. Treatments and input levels were adjusted from one cycle to the next by eliminating the less profitable alternatives. Cycle I was experiment station-type trials; cycle III was onfarm trials. In cycle I, the improved variety at high-input levels gave an increased yield of 0.5 ton per ha. In the second cycle, improved varieties with farmers' inputs and practices gave an increased yield of 0.1 ton per ha. With 80 kg per ha of applied fertilizer, the local variety yielded 2.9 tons per ha and the improved variety, 3.5 tons per ha. In the third cycle, yields of the improved variety were 0.2 tons per ha higher than farmers' varieties at farmers' input levels and 0.3 tons per ha higher than local varieties at high-fertilizer levels.

Cycle III experiments tested variety and nitrogen fertilizer; planting density, phosphorous fertilizer, and weed control had all been dropped because high levels of each could not be justified on the basis of their returns. Economic analysis of cycle III results showed that return to cash invested in fertilizer was quite good for landowners with both varieties of maize, but "fertilizer use in maize production is not economically available for sharecroppers".

Onfarm trials at 17 locations in Thailand showed that switching to an improved variety of maize with no fertilizer or other improved inputs increased yields by 0.1 ton per ha (49). By adding 50 kg per ha of N and 63 kg per ha of P_2O_5, yields increased only 0.4 ton per ha over fields not fertilized. Economic analysis showed that the cost of the fertilizer exceeded the value of additional production. Therefore profit was highest with the improved variety and other improved inputs.

Even where onfarm trials show that an alternative to farmer practice is profitable as well as higher yielding, there is still room to be misled. In many places, crops are grown as part of a system that requires one crop to be harvested before a second is planted. Yields normally increase with crop duration, but when another crop precedes or follows, farmers may prefer to sacrifice some yield and economic return from one crop in other to ensure profits from the other. Zeigler and Kayibigi recount such a case in which "improved" maize was not adopted in Burundi because "there may be a serious disadvantage to pursuing a selection strategy of maximizing maize yield with no regard for the other components of the system" (49).

It is obviously hazardous to generalize from such a small sample of experimental results. The onfarm trials reported in table 7 suggest that improved maize varieties may be expected to add no more than 1.0-ton-per-ha yield, and that improved varieties together with test levels of fertilizer and other inputs may add no more than 1.5 tons per ha in onfarm trials (table 7, yield increase 2). Economic analysis of the yield increases obtained from the high levels of fertilizer and other inputs often show that they are not profitable. That was the case for the trials in Haiti and Thailand. The relevant yield increase is, therefore, shown as yield increase (1) in table 7. These data support the hypothesis that there is little evidence of a large exploitable yield gap for maize.

Sorghum and Millet

High-yielding hybrid varieties of sorghum and millet were developed for the semiarid areas of India during the sixities. By the eighties, they had spread quite widely. These hybrids, like

Table 7--Performance of improved maize technology in onfarm trials

Location and number of trails	Level of variable inputs 1/			Yield	Yield increases 3/		Source
	Variety	Fertilizer	Other inputs 2/		1	2	
				Tons per ha			
Mexico	F	F	F	2.0			(34)
26	T	F	F	2.0	-	-	
	F	T	T	3.1			
	T	T	T	3.4	0.3	1.4	
Ghana	F	F	F	1.8			(34)
418	F	F	F	3.5	-	1.7	
74	F	F	F	2.8			(34)
	T	F	F	3.9	1.1	-	(34)
Guatemala	F	F	F	2.9			(34)
23	T	F	F	4.0	1.1	-	
Paraguay	F	F	F	2.7			(34)
24	T	F	F	3.0	.3	-	
Haiti:							
I.1, 5	F	T	T	3.1			(34)
	T	T	T	3.6	.5	-	
I.2, 8	F	F	F	1.5			(47)
	F	T	T	2.5	-	1.0	
II, 4	F	F	F	2.3			(47)
	T	F	F	2.4	.1	-	
	F	T	F	2.9			
	T	T	F	3.5	.6	.8	
III.1, 8	F	F	F	2.1			(47)
	T	F	F	2.3	.2	-	
	F	T	F	2.6			
	T	T	F	2.9	.3	.8	
III.2,	F	F	F	1.1			(47)
	T	F	F	1.3	.2	-	
	F	T	F	1.8			
	T	T	F	2.1	.3	1.0	
Thailand	F	F	F	3.6			(18)
17	T	F	F	3.7	.1	-	
	T	F	T	4.0	-	.4	
	T	T	T	4.4	.4	.8	

1/ F = farmer's variety and level of inputs or low-added fertilizer; T = test variety or high level of inputs.
2/ Usually insect and weed control, often plant density.
3/ Yield increase in column 1 is the difference between the farmer' variety and experimental variety at fixed levels of fertilizer and other inputs. Yield increase in column 2 is the difference due to other inputs with variety held fixed.

semidwarf rice and wheat, were more highly responsive to fertilizer than were local varieties (35), and they apparently were attractive to many Indian farmers who adopted them.

By 1983-84, hybrid pearl millet covered 43 percent of the millet area and hybrid sorghum 29 percent of the sorghum area of India. In some producing areas, they spread even more rapidly--to 85 percent of the pearl millet area of Gujarat State and to 50 percent of the kharif (summer) sorghum area of Maharashtra. Only about 19 percent of the millet area and 12 percent of sorghum area were irrigated (45).

Analysis of the adoption of hybrid sorghum shows little use in areas where sorghum is mainly grown as a rabi (winter) crop. The adoption process seems to have been largely completed by the late seventies in the sense that adoption had reached a plateau, although at significantly less than 100 percent. Walker and Singh believe that to break these "ceilings" of adoption, second and third generation hybrids and varieties will have to be released (45).

These and other improved varieties and test lines from India have been widely tested in Africa but have not spread to the sorghum and millet producing areas of Africa. No statistical estimates exist, but two ICRISAT economists reported that probably less than 2 percent of

total sorghum and millet area in west Africa is cultivars developed through modern genetic research (26).

This is true despite experiments in Burkina Faso that showed average yields with improved sorghum varieties of 1.9 tons per ha on the experiment station, compared with farmers' yields of 1.2 tons per ha. Improved millet yields were 1.3 tons per ha at the station, compared with 0.5 ton per ha for farmers' yields.

In a critical review of sorghum and millet improvement research, Matlon observered that some sorghum and millet varieties are acceptable in India and not acceptable in west Africa (26). Some of the reasons are: Most sorghum soils in west Africa have lower water-holding capacity and lower ion exchange capacity and as a consequence plant population must be lower. The rainy reason in west Africa lasts a shorter period even though it may provide as much rain. Extension support and infrastructure to supply chemicals is much less developed in west Africa. For these reasons, Matlon argues that varieties developed to give high yield with high inputs are inappropriate. New cultivars should be at least as tolerant or resistant to stresses (striga, downy mildew in millet, drought, sooty stripe, grain mold, and charcoal rot in sorghum) as local varieties, and they should provide a wider range of agronomic characteristics such as plant canopy or duration.

There must be development within Africa. Among 7,000 sorghum introductions screened by ICRISAT in Burkina Faso, 9 cultivars were found sufficiently promising in onstation trials to warrant onfarm tests. Of these, only two cultivars have been found to be generally superior under farmer's conditions. Among 3,000 millet entries screened, 5 cultivars advanced to onfarm tests, but no superior cultivars have yet been identified (25). A program to develop improved sorghum and millet varieties that will raise production and be acceptable to west African farmers is under way at the ICRISAT subcenter in Niger, but it will require some time to produce appropriate varieties.

Potential Medium-Term Productivity Increases

The discussion thus far has focused on potential for increasing production using technologies that can be examined at experiment stations although they are not widely used on farmers' fields. What is the future potential for developing still more productive technologies? Past yield gains have come through improving plants and the environment in which they are grown. A large share of the environmental improvement has been in the form of water and nutrient control that requires capital investment or current expenditures. Economic incentives to apply fertilizer nutrients, improve management, or invest in water control are interrelated with the capacity of plants to make productive use of the "improved environments," a capacity that is generated through plant breeding.

H. K. Jain has examined the record of wheat, rice, barley, and sorghum yield increases during the past 80 years of crop breeding (24). He concludes that most of the genetic basis for the observed yield gains have been achieved through redistribution of dry matter between vegetative and reproductive plant parts and that "there is little evidence to show that biological yield or the dry matter production has seen a significant increase during this period. Other authorities agree (12).

Jain observes that crops were selected over thousands of years to survive under stressful conditions. This process produced plants with high vegetative vigour and a minimum, but well assured, grain output. The deliberate effort of plant breeders to increase grain production has largely taken the form of increasing the ratio of output useful to man (such as, seeds in cereals) to total dry matter production, as illustrated in figures 10-13. This ratio, called the harvest index, it closely associated with plant height. Reducing plant height in the small grain crops has been the principal means by which harvest index and crop yield were raised,

Figure 10

Wheat in the United Kingdom

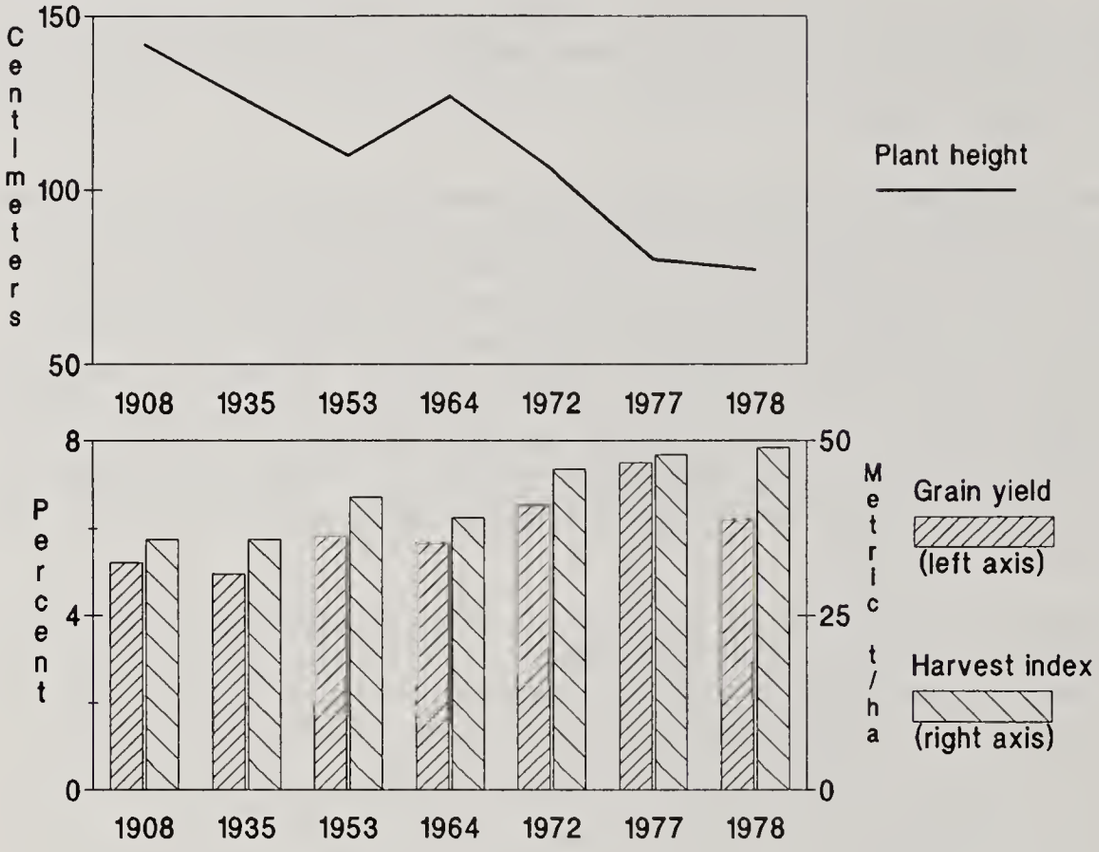


Figure 11

Wheat in India

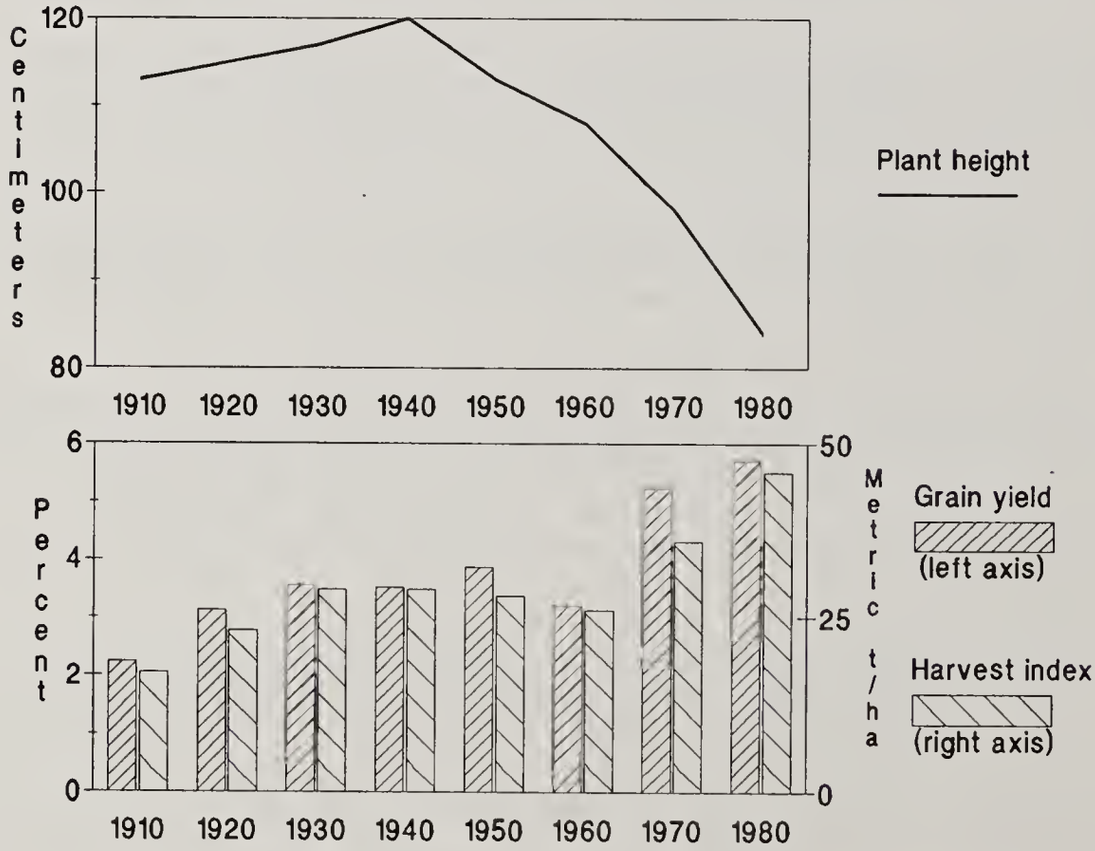


Figure 12

Sorghum in India

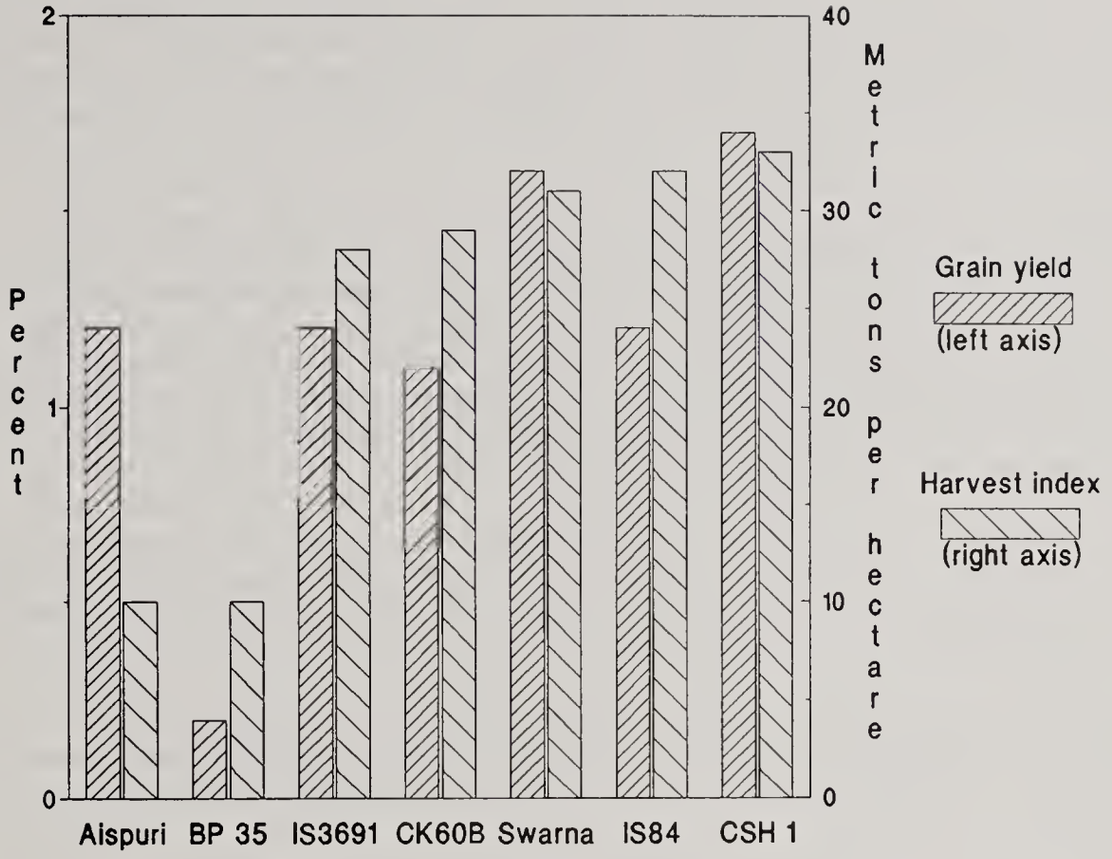
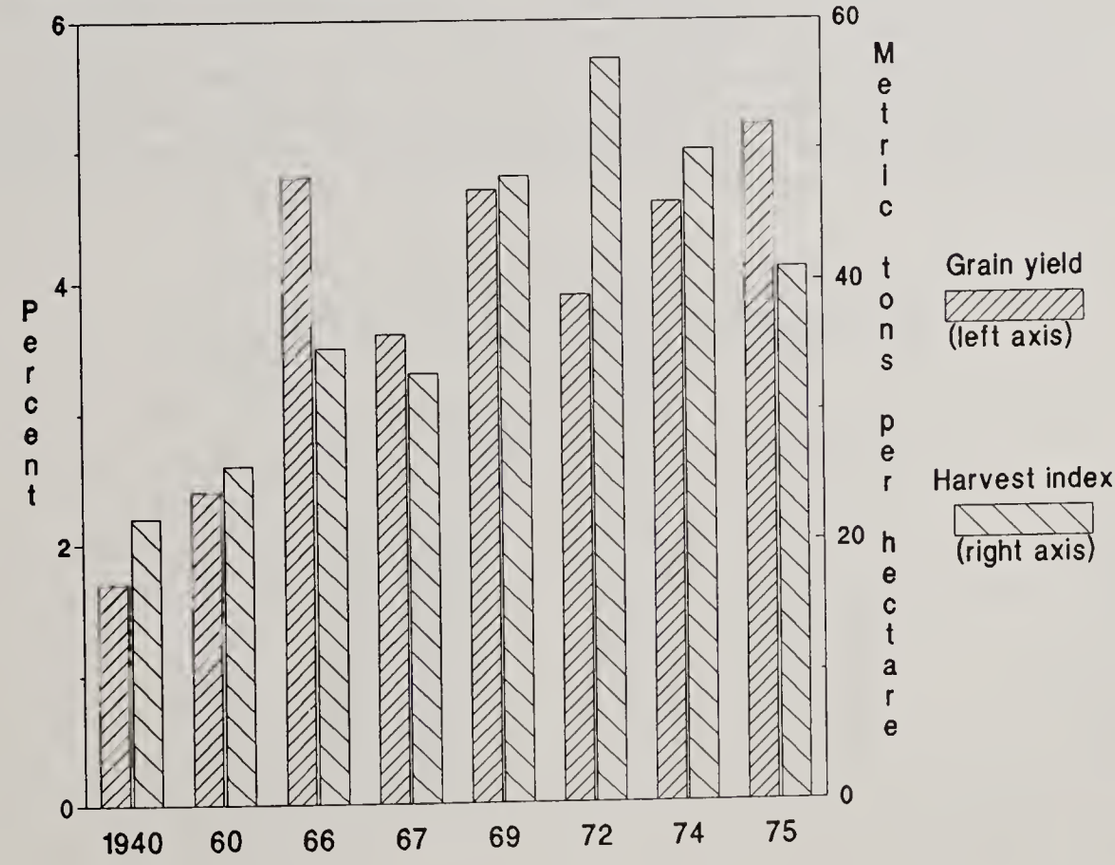


Figure 13

Rice in the Philippines



although maize seems to be different (11). The shortening process occurred gradually in the developed countries as illustrated for wheat varieties between 1908 and 1970 in the United Kingdom, but it occurred much more suddenly with the introduction of semidwarf varieties in the developing countries (wheat and sorghum in India and rice in the Philippines). The question facing agriculture in those countries is whether further scope exists for this kind of manipulation, and if not, what the source of future increases in yield potential will be.

Jain suggests that in developed countries some of the crops are beginning to reach yield plateaus. Citing other researchers from the United States and the United Kingdom, Jain concludes that the harvest index for wheat could possibly be further increased from its present level of 50 percent to 60 percent, after which total dry matter production (biomass) will have to be increased if grain yields are to be further increased. A similar conclusion might be warranted for developing countries that produce semidwarf rice and wheat. They have harvest index levels approaching 50 percent. The harvest index of improved sorghum and millet in India has reached about 30 percent, but as pointed out earlier no change has occurred in the commonly cultivated varieties in Africa.

The potential for improving maize yields in developing countries through genetics appears to be considerable, judging from advances made in the developed world. How quickly a similar improvment can be realized in the developing countries is difficult to judge, but I believe there is still some work to do.

An examination of yield trends of major crops in the developed world provides some indications of the inherent capacity of crops to respond to plant breeding. Table 8 shows such a comparison. Average grain yields in North America and Europe increased by a low of 70 percent for millet and a high of 307 percent for maize between 1948-52 and 1981-83, excluding rice in Europe which had a very high yield to begin with. Yield gains for other major crops seem to be somewhat less than for the major grains, although dry bean yields in Europe and peanut yields in North America increased over 160 percent. Soybean yields in Europe increased by nearly 96 percent, showing that yields of these crops have been increasing, but not quite as dramatically as yields of grains. In the developing regions, yields of most crops have increased much less, suggesting that there is genetic capacity for yield improvements if the appropriate research is done. The examples of millet and sorghum in west Africa and maize more generally show that there is no easy transfer of technology from one agricultural ecology to another, even when the ecologies appear to be similar. Research must be conducted in the agro-ecology for which the technology is intended.

Table 8--Major crops: Yields and yield changes in North America and Europe

Crop	North America			Europe		
	1948-52	1981-83	Percentage change	1948-52	1981-83	Percentage change
	Tons per hectare		Percent	Tons per hectare		Percent
Wheat	1.16	2.32	100	1.47	3.77	157
Maize	2.49	6.37	155	1.24	5.05	307
Rice paddy	2.56	5.26	105	4.27	5.07	19
Sorghum, millet	1.24	3.59	190	.85	1.45	70
Barley	1.45	2.69	85	1.68	3.41	103
Potatoes	15.58	29.17	87	13.78	19.02	38
Sweet potatoes	5.88	13.57	131	15.10	10.67	-30
Dry beans	1.19	1.58	33	.22	.58	166
Chickpeas	NA	NA	NA	.43	.58	36
Soybeans	1.43	1.96	37	.64	1.26	96
Peanuts, in shell	.94	2.49	164	NA	NA	NA

NA = Not available
Source: (13).

Summary and Conclusions

As the evidence suggests, there is relatively little under-utilized technology waiting for developing country farmers to adopt. Existing technologies, such as semidwarf wheat and rice, will spread further only at a modest pace. There is no apparent "breakthrough" just over the horizon. Maize, sorghum, and millet technologies, which would be substantial improvements over what exists, will take time to develop. Biotechnology's promise is somewhat uncertain, but it is clear that time will be required before that promise is at hand.

Research trials are misleading indications of absolute potential; their trends lead trends in farmer's production but a gap between the two is normal. Developing country farmers are responsive to opportunities offered by new technologies or changed economic conditions and rapidly adopt technologies that benefit them. Researchers are often mislead about what may be beneficial to farmers for a number of reasons: (1) they use inappropriate prices; (2) they fail to account for all costs facing farmers; (3) assume that farmers' production conditions are represented by experiment stations; and (4) they forget that reseachers normally maximize yields rather than optimize input levels. Thus, biological researchers tend to overestimate the advantage of new technologies compared with farmers' current practices.

Prices, and hence enforced price policies, can have significant effects on incentives to adopt new technologies, so it is conceivable that some technologies that are not sufficiently profitable to be attractive under current policies could be made somewhat more attractive. Policy changes cannot compensate for the lack of technical (yield) advantages, which appears to be the explanation for the difference between the observed rates of technical change for wheat and maize. Potentials for new technologies exist on every front, but all require further investment of research time and effort.

It seems to me that a faster, not a slower, rate of technical change will be needed to enable developing countries to keep domestic food production at a rate that will meet consumer needs and provide the basis for economic growth. Going beyond the data reviewed in this paper, I believe there is adequate basis for the following scenario. In the absence of technical change, agriculure in most developing countries will grow too slowly to permit adequate overall economic growth rates, which, in turn, will make it impossible for developing countries to import food for domestic consumption. On the other hand, if their agricultural sectors and incomes grow 3-4 percent per year, their food demand will probably outpace economic growth rates, making food imports necessary and feasible.

REFERENCES

(1) Ashby, Jacqueline. Participation of Small Farmers in Technology Assessment, International Fertilizer Development Center, Muscle Shoals, AL, 1984.

(2) Barker, Randolph, and Robert W. Herdt, with Beth Rose. The Rice Economy of Asia, Resources for the Future in cooperation with the International Rice Research Institute, Washington, DC, 1985.

(3) Byerlee, Derek, P.R. Hobbs, B.R. Kahn, A. Majid, M. Ramzan Akhtar, and Naeem I. Hashmi. Increasing Wheat Productivity in the Context of Pakistan's Irrigated Cropping Systems: A View from the Farmer's Field, PARC/CIMMYT paper 86-7, 1986.

(4) CIMMYT. 1985 CIMMYT World Wheat Facts and Trends, Mexico City, 1986.

(5) _____. Research Highlights 1984, Mexico City 1985.

(6) Collinson, M. "On-Farm Research with a Systems Perspective: Its Role in Servicing Technical Component Research in Maize, with Examples from Eastern and Southern Africa," To Feed Ourselves: Proceedings of the First Eastern, Central and Southern Africa Regional Maize Workshop, Lusaka, March 10-17, 1985, pp. 229-236.

(7) Dalrymple, Dana. Development and Spread of High-Yielding Wheat Varieties in Developing Countries, USAID, Washington, DC, 1986.

(8) _____. Development and Spread of High-Yielding Rice Varieties in Developing Countries, USAID, Washington, DC, 1986.

(9) _____. Development and Spread of High-Yielding Varieties of Wheat and Rice in the Less Developed Nations, FAER-95. U.S. Department of Agriculture in cooperation with U.S. Agency for International Development, Washington, DC, 1978.

(10) De Datta, S.K., F.V. Garcia, W.P. Abilay, Jr., J.M. Alcantara, A. Mandac, and V.P. Marciano, "Constraints to High Rice Yields," Farm-Level Constraints to High Rice Yields in Asia: 1974-77, IRRI, Los Banos, Philippines, 1979.

(11) Duvick, Donald N. "Genetic Contributions to Yield Gains of U.S. Hybrid Maize, 1930 to 1980," Genetic Contributions to Yield Gains of Five Major Crop Plants, American Society of Agronomy and Crop Science Society of America, Madison, WI, 1984.

(12) Evans, L.T. "The National History of Crop Yield," American Scientist, Vol. 68, 1980, pp. 388-397.

(13) FAO. Production Yearbook, Vol. 37, Rome, Italy, 1983.

(14) Fargo Agricultural Experiment Station. Personal communication, Fargo, ND, 1986.

(15) Flynn, J.C., and S.K. De Datta, "Trends in Irrigated-Rice Yields under Intensive Cropping at Philippine Research Stations," Field Crops Research, Vol. 9, 1984, pp. 1-15.

(16) Gelaw, B. "CIMMYT's Maize Improvement Role in East, Central and Southern Africa," To Feed Ourselves: Proceedings of the First Eastern, Central and Southern Africa Regional Maize Workshop, Lusaka, March 10-17, 1985, pp. 208-228.

(17) Ghodake, R.D., and T.S. Walker. Yield Gap Analysis in Dryland Agriculture, Perspectives and Implications for the Eighties, ICRISAT, India, 1982.

(18) Harrington, Larry W., Rachain Thiraporn, and Sarun Wattanutchariya. "The Profitability of New Maize Technology: An Economic Analysis of 1983 On-Farm Verification Trials," 15th Thai National Corn and Sorghum Reporting Session, Apr. 16-20, 1984.

(19) Herdt, R.W. "An Overview of the Constraints Project Results" Farm-Level Constraints to High Rice Yields in Asia: 1974-77, IRRI, Los Banos, Philippines, 1979.

(20) _____ and C. Capule. "Adoption, Spread, and Production Impact of Modern Rice Varieties in Asia," IRRI, Los Banos, Philippines, 1983.

(21) _____ and A.M. Mandac. "Modern Technology and Economic Efficiency of Philippine Rice Farmers," Economic Development and Cultural Change, 29 (2) 1981.

(22) Herdt, R.W., and Thomas H. Wickham. "Exploring the Gap between Potential and Actual Rice Yield in the Philippines," Food Research Institute Studies, Vol. XIV, No. 2, Stanford Univ., Stanford, CA, 1975.

(23) International Rice Research Institute. Annual Report for 1984, and earlier years, , Los Banos, Philippines.

(24) Jain, H.K. "Eighty Years of Post-Mendelian Breeding for Crop Yield: Nature of Selection Pressures and Future Potential," Indian Journal of Genetics, 46 (Supplement), 1986, pp. 30-53.

(25) Matlon, Peter J. "A Critical Review of Objectives, Methods and Progress to Date in Sorghum and Millet Improvement: A Case Study of ICRISAT/Burkina Faso." Workshop on Technologies Appropriate for Farmers in Semi-Arid West Africa, Burkina Faso, April 2-5 1985.

(26) _____, and Dunstan S. Spencer. "Increasing Food Production in Sub-Saharan Africa: Environmental Problems and Inadequate Technological Solutions," American Journal of Agricultural Economics, Vol. 66 No. 5, Dec., 1984, pp. 671-676.

(27) Moock, Joyce (ed.) Understanding Africa's Rural Households and Farming Systems, Westview Press, London and Boulder, Co., 1986.

(28) Moshi, A.J., and W. Marandu. "Maize Research in Tanzania," in To Feed Ourselves: Proceedings of the First Eastern, Central and Southern Africa Regional Maize Workshop, Lusaka, March 10-17, 1985, p. 115.

(29) Mpabanzi, A., and E. Ntawuyirusha. "Maize Research in the Economic Community of the Great Lakes Countries (Burundi, Rwanda and Zaire)," in To Feed Ourselves: Proceedings of the First Eastern, Central and Southern Africa Regional Maize Workshop, Lusaka, March 10-17, 1985, p. 90.

(30) North Dakota Crop and Livestock Reporting Service. Agricultural Statistics of North Dakota, various issues

(31) Nyanteng, V.K. Riceland in West Africa: Distribution, Growth and Limiting Factors, Occasional Paper No. 7, West Africa Rice Development Association, Liberia, 1986.

(32) Ochieng, J.A.W. "Maize Research in Kenya," in To Feed Ourselves: Proceedings of the First Eastern, Central and Southern Africa Regional Maize Workshop, Lusaka, March 10-17, 1985, pp. 26-31.

(33) Perrin, Richard, and Donald Winkelmann. Impediments to Technical Progress on Small Versus Large Farms, CIMMYT, Mexico, 1976.

(34) Pham, H.N., S.R. Waddington, and J. Crossa. "Yield Stability of Improved Germplasm Developed and Distributed by the CIMMYT Maize Program," IFPRI/DSE Workshop on Sources of Increased Variability in Cereal Yields, Feldafing, November 26-29, 1985.

(35) Rao, P. Parthasarathy, and J.G. Ryan. Fertilizer Response of Improved Sorghum Cultivars at ICRISAT Center, ICRISAT, Patancheru, India, 1983.

(36) Ristanovic, D., and P. Gibson. "Development and Evaluation of Maize Hybrids in Zambia," in To Feed Ourselves: Proceedings of the First Eastern, Central and Southern Africa Regional Maize Workshop, Lusaka, March 10-17, 1985. pp. 186-196.

(37) Rosegrant, Mark W., and James A. Roumasset. "The Effect of Fertilizer on Risk: A Heteroscedastic Production Function with Measurable Stochastic Inputs," The Journal of Australian Agricultural Economics Society, Vol. 29, No. 2, 1985, pp. 107-121.

(38) Ruttan, Vernon, and Randy Schoenek. The Geography of Soybean Yields, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, 1982.

(39) Shikhulu, J.P., and E. Mavimbela. "Maize Research Activities in Swaziland," in To Feed Ourselves: Proceedings of the First Eastern, Central and Southern Africa Regional Maize Workshop, Lusaka, March 10-17, 1985, pp. 100-111.

(40) Singh, Khem. "Changing Patterns of Variability and Future Strategies for Cereal Production in India," IFPRI/DSE Workshop on Sources of Increased Variability in Cereal Yields, Feldafing, Nov. 26-29, 1985.

(41) Swaminathan, M.S. "Foreword," Potential Productivity of Field Crops Under Different Environments, IRRI, Los Banos, 1983.

(42) Swanson, Earl R., Donald G. Smith, and James C. Nyankori. "Have Corn and Soybean Yields Reached a Plateau?, Illinois Agricultural Economics, Staff Paper No. 77 E-17, 1977.

(43) University of Illinois. The Morrow Plots: A Century of Learning," Bulletin 775, Urbana-Champaign, IL, 1982.

(44) U.S. Department of Agriculture. Agricultural Statistics, various issues, 1985.

(45) Walker, T.S., and R.P. Singh. "Improved Seeds of Change in Dryland Agriculture: Promise and Implications for Economics Research," Seminar on Technology Options and Economic Policy for Dryland Agriculture: Potential and Challenge, Aug. 22-24, 1983.

(46) Weber, Adolf. Assessing the Theoretical Maximum of World Food Production, n.d.

(47) Yates, Michael, and Juan Carlos Martinez. "On-Farm Research Methodologies at Work." Progress Report from Les Cayes, Haiti, 1984.

(48) Yoshida, S. "Rice," Potential Productivity of Field Crops under Different Environments, IRRI, Los Banos, 1983.

(49) Zeigler R.S., and M. Kayibigi. "Farmer Rejection of Late Maturing, High-Yielding Maize in Burundi," To Feed Ourselves: Proceedings of the First Eastern, Central and Southern Africa Regional Maize Workshop, Lusaka, March 10-17, 1985, pp. 12-19.

CHANGING PATTERNS OF CONSUMPTION UNDERLYING CHANGES IN TRADE AND AGRICULTURAL DEVELOPMENT

Per Pinstrup-Andersen[1]

The patterns of food consumption have changed significantly in many countries during the past 10-20 years. These changes influence and are influenced by patterns of production and trade and, if continued at current rates, will result in considerable changes in future demand patterns.

This paper provides an empirical overview of recent and expected future changes in consumption patterns for food and discusses the factors expected to be most important in influencing these changes.

Several factors influence consumption patterns. The most important are changes in incomes, income distribution, relative prices, and the rate of urbanization. Changes in the opportunity cost of women's time, intrahousehold budget control, and tastes, as well as increasing commercialization of semisubsistence agriculture may also contribute.

Long-Term Changes in Food Consumption Patterns: A Statistical Overview

The change in food consumption patterns during the sixties and seventies differs among regions and level of development (table 1). The well-known shift from foods of vegetarian origin to animal products is common to all regions. The rate of change is strongest in Eastern Eurpoe and the USSR. With about two-thirds of all calories coming from vegetarian sources and one-third from animal origin, the developed market economies appear to have reached a level where no further substitution between the two groups is desired. The developing countries are just entering into the phase of rapid substitution and are still in the phase of relatively large increases in the consumption of both categories of food.

Although the relative importance of the two food groups has changed little during the 20-year period under study, except for the East European countries and USSR, significant changes have occurred within each of the two food groups in all country groups. The most striking changes in the developed market economies were large increases in the consumption of meat, alcohol, and vegetable oils and fats and decreases in animal oils and fats, cereals, and roots and tubers. Similar changes occurred in the East European countries and USSR, except consumption of animal oils and fats increased. Sugar consumption, which increased only slightly in the developed market economies, showed a very marked increase in Eastern Europe and USSR. Sugar consumption increased in all regions of the developing world, as did vegetable oils and fats, eggs, and fish. The largest reductions were found in the consumption of roots and tubers, pulses, nuts, and seeds.

Regional averages cover large differences among countries. The most important reason for such differences is the level of income. Table 2 shows the change in calorie sources for 85 developing countries by income level and income growth rate for a 10-year period. A very clear relationship emerges between the per capita income level and the consumption patterns as well as changes in these patterns. Low-income countries rely heavily on cereals and roots and tubers, and the importance of these foods increased during the seventies. Higher income countries, on the other hand, obtain a smaller and decreasing proportion of their calories from these foods. The opposite change occurred for sugar and animal products--that is, their

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relative importance decreased for the poor and increased for the higher income developing countries. Thus, an increasing discrepancy in the diet composition between low- and high-income developing countries is evident during the 10-year period.

Countries with low-growth rates during the seventies tend to increase their reliance on cereals, while reducing the relative importance of animal products. High-growth countries, on the other hand, show large increases in the consumption of animal products and sugar, while reducing the relative importance of cereals and root crops (table 2). Changes in consumption patterns tend to be more strongly associated with income levels than with growth in income. No apparent relationship was found between changes in consumption patterns and the degree of food self-sufficiency.

Table 1--Share of major food groups in total calorie consumption by region and economic group

Food group	Developed market economies			Eastern Europe and USSR			Developing market economies			Africa		
	1961-63	1969-71	1979-81	1961-63	1969-71	1979-81	1961-63	1969-71	1979-81	1961-63	1969-71	1979-81
	Percent											
Vegetable products	69.2	68.4	68.3	77.6	75.0	72.9	91.9	91.9	91.4	93.7	93.5	93.5
Cereals	31.1	27.4	26.4	47.2	41.4	37.5	58.1	57.9	57.7	46.4	45.8	46.7
Pulses, nuts, and seeds	2.6	2.4	2.4	1.6	1.5	1.4	8.1	7.0	5.6	8.1	7.9	7.0
Roots and tubers	4.9	4.2	3.7	7.9	7.3	6.0	7.1	7.3	6.2	21.7	21.7	19.8
Sugar	12.6	13.5	13.0	10.0	12.0	13.0	8.5	9.2	9.7	3.6	4.1	5.2
Vegetables and fruits	4.6	5.0	4.8	2.7	3.0	3.6	4.1	4.3	4.4	5.4	5.2	4.8
Vegetable oils and fats	7.9	9.7	11.3	4.5	5.0	6.0	4.6	5.1	6.3	5.6	6.1	7.6
Stimulants and spices	.7	.8	.8	.2	.3	.4	.5	.4	.4	.8	.6	.5
Alcohol beverages	4.8	5.4	5.9	3.5	4.5	5.0	.9	1.0	1.1	2.1	2.1	1.9
Animal products	30.8	31.6	31.7	22.4	25.0	27.1	8.1	8.1	8.6	6.3	6.5	6.5
Meat and offal	12.8	14.3	15.3	7.1	8.2	9.9	3.0	3.0	3.1	3.1	3.0	2.8
Milk	9.1	8.6	8.5	8.6	9.3	8.5	3.1	2.9	3.1	1.8	1.9	2.0
Animal oils and fats	6.0	5.6	4.7	4.9	5.2	5.8	1.3	1.3	1.3	.6	.7	.7
Eggs	1.6	1.7	1.6	.9	1.1	1.5	.2	.3	.4	.2	.2	.2
Fish	1.3	1.4	1.6	.9	1.2	1.4	.5	.6	.7	.6	.7	.8

	Far East			Latin America			Near East			Asian centrally planned economies		
	1961-63	1969-71	1979-81	1961-63	1969-71	1979-81	1961-63	1969-71	1979-81	1961-63	1969-71	1979-81
	Percent											
Vegetable products	94.6	94.6	94.2	83.5	83.8	82.9	90.0	90.2	89.3	91.7	91.2	90.0
Cereals	66.7	67.6	67.4	40.4	39.6	40.2	64.9	61.7	58.2	63.5	66.2	66.9
Pulses, nuts, and seeds	9.2	7.4	5.9	6.4	6.3	4.9	4.8	4.4	3.8	6.6	4.5	3.5
Roots and tubers	3.3	3.3	3.0	7.4	7.9	5.6	1.6	1.6	1.8	15.6	14.3	12.0
Sugar	7.8	8.4	8.4	16.0	15.6	17.2	6.5	8.5	9.9	1.1	1.4	1.8
Vegetables and fruits	3.0	3.0	3.3	5.5	5.7	5.4	6.9	6.7	6.4	2.4	2.2	2.2
Vegetable oils and fats	4.0	4.1	5.3	5.2	6.0	6.7	4.8	6.7	8.4	1.6	1.8	2.6
Stimulants and spices	.5	.5	.5	.3	.3	.3	.3	.3	.4	.1	-.-	-.-
Alcoholic beverages	.1	.3	.4	2.3	2.4	2.6	.2	.3	.4	.8	.8	1.0
Animal products	5.4	5.4	5.8	16.5	16.3	17.1	10.0	9.8	10.7	8.3	8.8	10.0
Meat and offal	1.0	1.1	1.2	8.4	7.8	8.1	3.6	3.6	4.0	6.0	6.4	7.4
Milk	2.7	2.3	2.5	5.0	5.2	5.5	3.8	3.4	3.7	.5	.4	.5
Animal oils and fats	1.0	1.1	1.1	2.2	2.1	2.0	2.2	2.3	2.3	.7	.8	.9
Eggs	.1	.2	.3	.5	.6	.8	.2	.3	.4	.7	.7	.7
Fish	.6	.7	.7	.4	.5	.7	.2	.2	.3	.4	.5	.5

Source: (11).

Shifts in food consumption patterns can be very rapid, as exemplified by Japan during the rapid growth period of 1955-78 and, to a lesser extent, by the Organization for Economic Cooperation and Development (OECD) during the same period (table 3). In Japan, the proportion of calories coming from cereals and starchy foods dropped from three-fourths to less that half, while consumption of meats and eggs increased 8.5 percent. Cultural differences may play an important role in consumption patterns, but it is realistic to expect that changes of similar magnitudes will occur in many developing countries as they move toward higher income levels.

Table 2--Sources of calories consumed in various groups of developing countries

Item	Countries	Share of total consumption from -- Cereals		Roots and tubers		Pulses and nuts		Animal products		Sugar		Other Foods	
		1969-71	1979-81	1969-71	1979-81	1969-71	1979-81	1969-71	1979-81	1969-71	1979-81	1969-71	1979-81
	Number	Percent											
Average	85	51.4	51.0	10.2	9.4	5.7	5.2	10.7	11.0	8.3	8.8	13.7	14.6
Grouped by 1980 per capita income 1/													
Less than $250	11	54.4	56.3	13.7	14.3	9.0	8.0	7.4	6.4	3.9	3.8	11.6	11.4
$250-$499	20	54.4	55.3	15.2	13.8	7.0	6.6	7.6	7.1	5.2	5.1	10.7	12.1
$500-$1,999	39	50.3	49.7	9.5	8.3	4.9	4.5	10.7	11.0	9.6	10.8	15.0	15.7
$2,000 and over	15	48.4	44.8	2.7	2.5	3.7	3.2	17.2	19.3	12.4	12.5	15.5	17.7
Grouped by 1961-80 income growth 2/													
Less than 1 percent	18	49.8	51.1	15.4	14.5	5.8	5.4	9.8	9.0	6.5	6.6	12.6	13.3
1.0-2.9 percent	32	48.4	48.5	12.8	12.1	6.5	5.8	9.9	10.0	7.7	8.1	14.7	15.6
3.0-4.9 percent	23	54.1	52.9	6.2	5.3	5.3	5.0	11.2	11.8	9.7	10.3	13.5	14.6
5.0 percent and over	12	56.7	53.9	3.0	2.1	4.2	3.7	13.0	15.0	10.2	11.2	12.9	14.1
Grouped by food self-sufficiency in 1976-80 3/													
Less than 75 percent	28	52.6	50.9	3.3	2.9	4.4	4.1	14.1	14.8	11.5	11.6	14.1	15.6
75-94 percent	24	47.0	48.6	18.3	16.4	6.0	5.3	7.8	7.9	6.2	7.0	14.7	14.8
95-104 percent	17	54.2	53.9	13.5	12.7	6.7	6.1	8.6	8.6	5.9	6.0	11.1	12.7
105 percent and over	16	53.2	51.7	6.4	6.5	6.4	5.9	11.4	11.5	8.5	9.6	14.1	14.7

1/ 1979-81 U.S. dollars.
2/ Average annual growth rate of real GNP per capita, 1961-80.
3/ Ratio of domestic production to total consumption of major crops during 1976-80.

Source: The country groupings are based on Paulino (17). Data on sources of calories by country are Agriculture Organization of the United Nations (11).

Table 3--Sources of calories consumed in the OECD and Japan,

Food groups	OECD 1955-57	OECD 1976-78	Japan 1955-57	Japan 1976-78
	Percent of total calorie consumption			
Cereals and starchy foods	40.3	30.1	74.9	49.3
Meats and eggs	13.9	19.4	2.1	10.6
Oils and fats	15.4	18.0	3.4	12.4
Sugar	12.4	13.0	5.9	10.6
Milk	11.0	11.7	0.9	3.5
Fruits and vegetables	4.0	4.9	3.2	4.7
Pulses and nuts	1.8	1.6	6.2	4.8
Fish	1.1	1.2	3.4	4.1

Source: (3).

Average figures for cereals shown in earlier tables cover large differences among the various cereal types. While the annual growth rate for cereals used for food in developing countries during 1961-83 was 3.3 percent, wheat consumption grew at an annual rate of 5.2 percent (table 4). Similarly, maize consumption for food in developed countries grew 2.2 percent annually, compared with an average growth rate of 0.5 percent for all cereals for food. Consumption of cereals by animals grew at very high rates, reaching 11.5 percent for maize in Asia.

Considerable differences were also found within animal products. Beef and pig meat each accounted for 30-40 percent of total meat consumption in both developed and developing countries. The relative importance of beef and buffalo fell significantly in developing countries from the early sixties to the midseventies, while pig meat gained (table 5). The most significant development was the rapid increase in the importance of poultry meat in all regions. The annual average growth rates for poultry meat were 9.8 percent in North Africa and the Middle East and 7.8 percent for all developing countries (table 6).

Table 4--Annual growth rates in the consumption of various grains by region, 1961-83 average

Region	Wheat		Rice		Maize		Other coarse grain		Total cereals	
	Feed	Food	Feed	Food	Feed	Food	Feed	Food	Feed	Food
	Percent									
Developing economies	6.00	5.23	3.36	3.31	7.52	2.88	4.18	0.72	5.55	3.34
Asia	6.58	5.88	3.35	3.24	11.53	2.84	1.53	.30	6.00	3.37
North Africa and Middle East	5.46	4.31	1.04	4.53	7.92	2.66	3.38	.96	4.68	3.65
Sub-Saharan Africa	7.66	6.23	3.20	5.06	5.27	3.27	1.60	1.40	3.86	2.85
Latin America	4.87	3.45	4.32	3.46	4.20	2.77	9.10	3.36	5.36	3.19
Developed economies	4.06	.45	1.46	.40	2.90	2.16	2.11	.31	2.81	.5
North America	2.17	1.19	1.36	2.92	1.68	1.94	-.01	2.41	1.04	1.54
Eastern Europe	5.68	.20	9.84	7.15	5.30	-.01	4.43	-.01	4.99	.19
Western Europe	2.18	.09	5.25	1.55	3.67	1.20	1.37	.99	2.25	.33

Source: (11).

Table 5--Percentage of total meat consumption by region

Region	Beef and buffalo		Mutton and goat		Pig meat		Poultry meat	
	1961-65	1973-77	1961-65	1973-77	1961-65	1973-77	1961-65	1973-77
	Percent of total meat consumption							
World	39.2	37.6	8.2	6.0	38.1	37.6	14.5	18.8
Developed economies	39.3	39.6	6.6	4.4	38.6	36.2	15.5	19.8
Developing economies	39.1	33.7	11.2	9.0	37.1	40.5	12.7	16.8
Asia	35.6	33.4	19.8	17.2	31.1	31.9	13.5	17.5
North Africa/Middle East	38.3	35.8	48.9	41.9	0.5	0.7	12.3	21.6
Sub-Saharan Africa	59.8	57.9	24.4	20.6	5.9	7.6	10.0	14.0
Latin America	70.8	63.9	5.1	3.4	16.4	17.0	7.7	15.7

Source: (23).

Table 6--Annual growth rates of meat consumption by type and region, 1961-77

Region	Total	Beef and buffalo	Mutton and goat	Pig meat	Poultry meat
			Percent		
Asia	2.9	2.3	1.6	3.2	5.4
North Africa and Middle East	4.1	3.2	2.8	3.0	9.8
Sub-Saharan Africa	2.0	1.7	.7	4.4	4.8
Latin America	3.3	2.4	NA	3.3	9.2
Developing countries 1/	3.2	2.4	1.7	3.3	7.8

NA = Not available.
1/ Includes 104 countries
Source: (23).

The Impact of Income Growth

Much of the change in consumption patterns can be explained by changes in incomes. Income elasticities are generally much higher for animal products than for cereals and other staples. As shown in table 7, income elasticities for meats and eggs may be close to 1 in regions with low consumption of these commodities, while it is generally around 0.2 for cereals used for food. In Latin America, meat consumption is relatively high and income elasticities are relatively low. In most developed countries, increased incomes cause the consumption of cereals for food to decline, as expressed by the negative income elasticity (table 7).

The strong effect of income on meat consumption is reflected in very large differences in meat consumption among developing countries at various income levels (table 8). Developing countries with annual per capita incomes of $1,250 or more consume almost nine times the amount of meat that is consumed in countries with incomes below $250.

Table 7--Income elasticities of demand for livestock products and cereals, 1975

Region	Meat	Milk	Eggs	Cereals
Developed economies	0.25	-0.05	0.27	0.22
Developing economies 1/	.63	.57	1.00	.16
Africa	.79	.68	1.05	.21
Asia and Far East	.97	.52	1.07	.22
Near East	.72	.53	.83	.13
Latin America	.37	.49	.60	.16

1/ Grouped according to the classification system of the Food and Agriculture Organization of the United Nations.
Source: (23).

Table 8--Average annual per capita consumption of meat for 1973-77, by per capita income group in 1977

Region	Per capita income group			
	Less than $250	$250-$499	$500-$1,249	$1,250 or more
		Kilograms per year		
Asia	2.8	6.9	10.2	56.8
North Africa and Middle East	8.9	12.4	14.6	18.3
Sub-Saharan Africa	10.2	7.5	14.1	27.4
Latin America	10.6	19.2	22.8	38.5
All study countries	4.0	8.1	15.9	35.0

Source: (23).

Table 9--Income elasticities for calorie intake from various foods by income groups, Brazil, 1974/75

Food group	Lowest 30 percent		Highest 20 percent	
	Urban areas	Rural areas	Urban areas	Rural areas
Cereals	0.649	1.00	0.071	0.121
Rice	.852	1.99	-.224	.173
Maize	1/.329	1.18	1/-.043	2/ -.088
Wheat bread	1.09	1.47	.145	2/.127
Roots, tubers, and pulses	-.709	2/ -1.09	1/ .088	-.411
Cassava flour	-2.09	-3.50	1/ .330	-.356
Sugar	.652	1.25	-.033	1/ .077
Legumes	1/ -.202	2/ -.343	-.178	.079
Vegetables	1.27	2/ 1.52	.102	2/.266
Fruits	-.027	.380	.399	.078
Meat and Fish	.413	1/.363	.238	.075
Beef	1.45	1/ 1.22	.149	2/.154
Dairy products	.809	1.52	.373	.055
Milk	1/.727	2.27	.061	2/ -.172
Eggs	1.15	1.93	.100	2/.114
Oils and fats	1.56	2.53	-.040	2/ -.315
Total calories	-.280	.465	.039	2/.057

1/ This is not significantly differenct from zero at the 0.05 level using a two-tailed test.
2/ This is not significantly different from the urban estimate at the 0.05 level using a two-tailed test.
Source: (32).

The effect of income on consumption of the various foods within a given country is illustrated in table 9, using data from Brazil. Income elasticities for cereals are high for the poor, particularly the rural poor, while they are generally negative for the urban rich and low for the rural rich. Among the cereals, only wheat consumption increases when incomes among the urban rich increase. This reflects a strong desire to substitute wheat bread for other cereal-based foods, a phenomenon found in most higher income developing countries.

Another feature illustrated by the Brazilian data, which is common to most developing countries, is the high-income elasticity for sugar, vegetables, oils and fats, and meat and fish among the poor, together with low-income elasticities for roots, tubers, and pulses. The implications for future demand of various commodities in a situation of rapid income growth among the poor are obvious.

The strong desire of the poor to change their diet toward high-elasticity commodities is reflected in large differences between calorie and food expenditure elasticites. As shown in table 10, it is not uncommon for food expenditure elasticities to be twice the calorie elasticities. This implies rapidly increasing calorie costs of the diet with increasing incomes. While this is a well-known phenomenon, it is surprising to find that the poor, including many households with insufficient but nutritionally well-balanced food consumption to meet nutritional needs, choose to modify their dietary composition at such a rapid rate.

Table 10--Calorie and food expenditure elasticities for low-income families

Country	Urban areas		Rural areas	
	Calorie	Food expenditure	Calorie	Food expenditure
	elasticity			
Sri Lanka	0.41	0.72	0.60	0.86
Thailand	.26	.62	.29	.65
Egypt	.20	.71	.34	.68
Sudan	.30	.74	.33	.84
Indonesia	.55	.88	.61	.98
Brazil	.28	.83	.47	.83
Bangladesh	.40	1.06	.40	1.06
Phillippines	--	--	.32	.66
India, North Arcot	--	--	.41	.87

-- = Not available.
Note: Low income is defined as the average income of families that consume 1,750-2,000 calories per capita per day.
Sources: (1,15,20,32).

The Effect of Relative Prices

The magnitudes of the income and price elasticities (in absolute values) among commodities and population groups are usually positively correlated. Both income and price elasticities (in absolute values) usually fall when incomes increase. While there is a direct relationship between the income effect of a price change, income elasticity, and the budget share, it also appears that the substitution effect decreases with increasing income, thus reinforcing the negative correlation between income level and the absolute value of the price elasticity (1, 28). There are two important implications of this finding. First, food price subsidies are less effective than expected in increasing calorie consumption, and second, the poor are more able and willing to cope with increasing food prices by substituting lower priced calories.

The variation of direct price elasticities among income strata and food commodities is illustrated in table 11. Large demand adjustments are made by the poor in response to price changes for rice, bread, beef, and milk, while the price elasticity for many foods is not significantly different from zero among the richest 20 percent of the population. This implies that price subsidies for unlimited quantities targeted to the poor are likely to result in relatively large demand increases for the subsidized commodities, even if they are financed by excise taxes on these commodities for the rich.

As mentioned above, consumers--particularly urban middle- and upper-income ones--in many developing countries view wheat bread as a preferred commodity. This is reflected in high-income and price elasticities. The natural environment is not well suited for wheat production in many of these countries. Price subsidies for wheat are common in many of these countries. The results are: 1) low prices for wheat bread relative to both international wheat prices an domestic prices of other staples (table 12), 2) rapidly increasing demand for wheat bread and associated increases in wheat import, and 3) a weakening of the demand for competing commodities.

This point is illustrated for Brazil in figure 1. Heavy and increasing consumer subsidies on wheat resulted in large reductions in the price of wheat relative to rice and bean prices, associated rapid increases in wheat consumption and imports, stagnation in the demand for rice and beans, and a reduction in the demand for roots and tubers. Similarly, heavy price subsidies for wheat bread and flour in Egypt resulted in dramatic increases in the consumption of wheat flour in rural areas and wheat bread in urban areas during the sixties and seventies (table 13). Tables 14 and 15 attempt to generalize this finding to a larger number of

Table 11--Own-price elasticities for calories from different foods by income group, Brazil, 1974/75

Food group	Income group		
	Lowest 30 percent	Middle 50 percent	Highest 20 percent
Cereals	-0.804	-0.173	1/ 0.163
	(.254)	(.142)	(.205)
Rice	-4.31	-2.95	-1.15
	(.482)	(.352)	(.243)
Maize	-1.77	-1.09	-.584
	(.198)	(.130)	(.141)
Wheat bread	-1.96	-.845	-.731
	(.197)	(.171)	(.181)
Roots	-1.36	-.758	1/ -.231
	(.187)	(.197)	(.179)
Cassava flour	-1.26	-1.05a	1/ -.319
	(.580)	(.606)	(.772)
Sugar	-1.39	-.962	-.588
	(.257)	(.202)	(.167)
Legumes	-.600	-.457	-.628
	(.236)	(.176)	(.250)
Vegetables	1/ -.410	1/ -.234	1/ -.267
	(.339)	(.183)	(.173)
Fruits	-.895	-.566	-.378
	(.409)	(.210)	(.168)
Meat and Fish	-.553	1/ -.140	1/ -.108
	(.228)	(.130)	(.160)
Beef	-2.35	-1.29	-.819
	(.195)	(.215)	(.209)
Dairy products	1/ -.270	-.636	-.845
	(.398)	(.269)	(.295)
Milk	-2.87	1/ -.095	1/ -.468
	(1.00)	(.651)	(.518)
Eggs	-(.770)	-.451	1/ -.124
	(.322)	(.163)	(.178)
Oils and fats	1/ -.337	1/ .375	1/ .356
	(.604)	(.388)	(.494)

Note: Numbers in parentheses are standard errors.
1/ This is not significantly different from zero at the 0.05 level, using a one-tailed test.
Sources: (32).

countries for the period 1970-80. The relationships between the change in real bread prices and the relative bread/rice price and net wheat import, is striking.

The principle implication for foreign trade and production is that price policy may cause very severe changes in consumption patterns and, thus, the composition of demand.

The Effect of Urbanization

The population growth rate in urban areas is very high in virtually all developing countries. It is expected that the proportion of the population of developing countries living in urban areas will increase from 30.8 percent in 1980 to about 43.8 percent by year 2000 (table 16). As illustrated in tables 17-18, urban and rural consumption patterns differ very significantly. Data for Tunisia show some of the differences commonly found in developing countries. The share of the diet coming from coarse grains and roots and tubers is generally much higher in

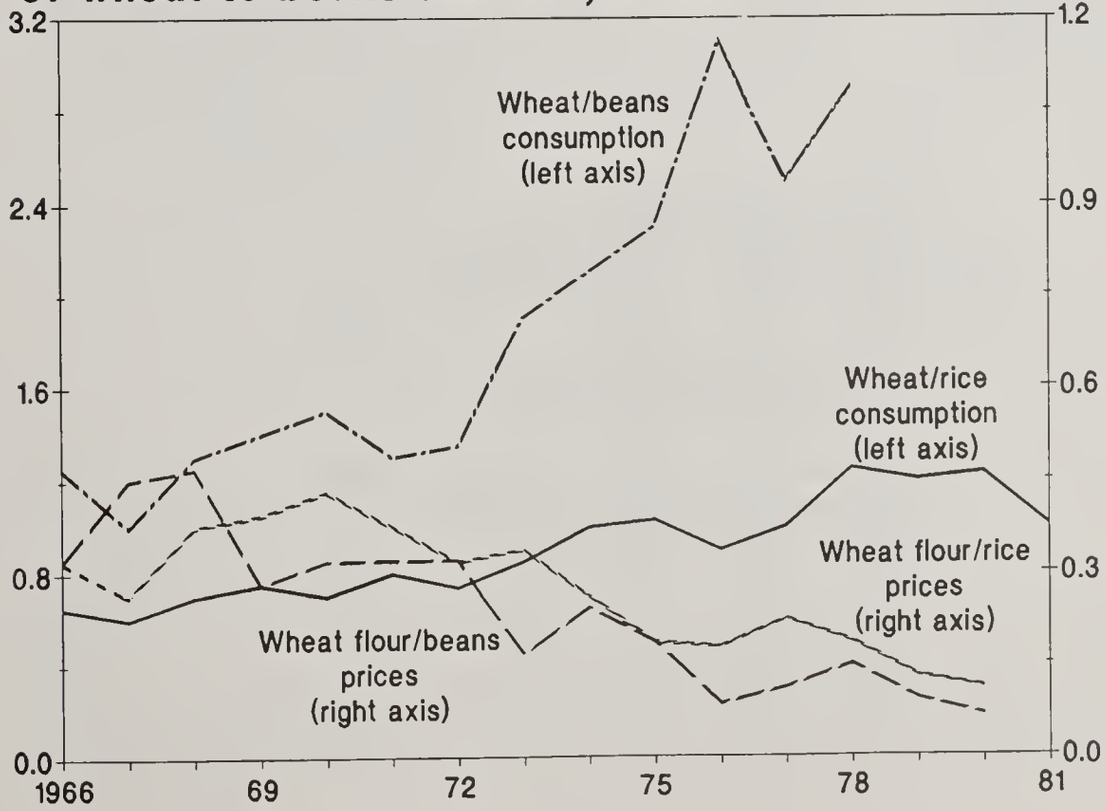
Table 12--Consumer prices of bread and rice in selected developing countries, 1980

Country	Bread price	Rice price	Price ratio bread/rice
	US$ per kilogram		
With bread subsidies:			
Egypt	0.09	0.20	0.45
Iraq	.20	.64	.29
Syria	.22	--	--
Morocco	.25	--	--
Sri Lanka	.26	.29	.89
Turkey	.30	1.28	.23
Mexico	.31	1.00	.31
Poland	.31	--	--
Israel	.31	.92	.33
India	.39	.24	1.63
Brazil	.39	.66	.54
Sudan	.40	2.25	.18
Pakistan	.45	.56	.80
Cuba	.46	.61	.46
Bolivia	.47	1.01	.46
Ivory Coast	.57	.47	1.21
Without bread subsidies:			
Zambia	.65	.68	.96
Tanzania	.72	1.47	.49
Panama	.82	.55	1.49
Hong Kong	.85	.66	1.28
Burma	1.06	.31	3.36
Costa Rica	1.11	.49	2.26
Cameroon	1.13	.70	1.60
Korea	1.14	1.11	1.03
Philippines	1.16	.34	3.41
Liberia	1.18	.62	1.90
Rwanda	1.83	.89	2.06

-- = Not available.
Source: (5).

Figure 1

Ratios of per capita consumption and retail prices of wheat to beans and rice, Brazil



rural than urban areas, while the opposite is true for wheat (and rice in some countries), vegetables, meat, oils and fats, and dairy products. Thus, increasing urbanization contributes to increasing demand for the latter, while the demand for the former is expected to be adversely affected.

One of the key questions is whether the difference between urban and rural consumption patterns can be explained by differences in incomes and relative prices. While the answer is likely to vary among countries and population groups, it appears that incomes and relative prices generally explain only part of the difference. Other factors that appear to be important are differences in: 1) the opportunity cost of women's time, 2) the cost of other basic needs, such as housing, and 3) the demonstration effects. This is an area where additional research on household behavior is likely to contribute to our ability to predict future commodity demand.

Table 13--Per capita food consumption in urban and rural Egypt

Food group	Rural areas				Urban areas			
	1958/59	1964/65	1974/75	1981/82	1958/59	1964/65	1974/75	1981/82
	Kilograms per capita							
Wheat grain	69.7	69.9	59.5	43.7	13.1	12.3	7.7	4.6
Maize	75.9	66.8	45.2	47.5	12.5	13.5	5.8	5.0
Rice	23.8	24.6	21.1	33.4	19.5	21.2	25.0	26.2
Wheat flour	16.1	22.5	40.7	143.0	33.4	8.0	25.4	44.5
Bread 1/	6.0	14.6	18.8	20.4	96.7	115.8	137.9	170.7
Beans	5.3	6.9	4.5	4.0	4.0	4.6	4.3	2.3
Lentils	3.2	4.5	3.1	3.6	3.3	4.2	4.1	1.8
Meat, poultry, and fish	12.5	13.2	13.6	30.5	19.4	19.9	19.0	35.3
Vegetables, oils, fats 2/	2.7	5.0	7.8	5.8	6.6	8.7	8.1	7.9
Sugar	10.0	11.6	13.4	23.5	11.4	12.2	13.0	25.1

1/ Bread is approximately 30-percent moisture by weight.
2/ 1981/82 oil only.
Source: (2).

Table 14--Changes in real price of bread and net wheat imports in selected developing countries

Annual average change in real price of bread, 1970.80	Country	Average rise in net wheat imports from 1961-65 to 1979-81
Percent		Kilograms per capita
-11. to -3.1	Algeria, Bolivia, Brazil, Dominican Republic, Egypt, El Salvador, Ethiopia, Ghana, Iran, Guatemala Iraq, Jordan, Kenya, Mexivo, Tanzania, Zaire	28
-3. to -.1	Burundi, Cameroon, Ecuador, India, Libya, Malawi, Morocco, Pakistan, Panama, Paraguay, Somalia Sudan, Tunisia	21
0 to 4.9	Chile, Colombia, Costa Rica, Hong Kong, Ivory Coast, Korea (Republic), Lesotho, Singapore, Thailand, Turkey Upper Volta, Urugay, Venezuela, Zambia	13
5 or more	Argentina, Bangladesh, Indoneisa, Malaysia, Peru, Philippines, Senegal, Sri Lanka	6

Source: (5).

The nature of the difference in urban and rural consumption patterns varies with income level. In general, the difference is more pronounced among the poor than the rich (table 18). For example, in Indonesia, the urban poor consumed three times the rice and only one-half the sugar consumed by rural poor, while the urban and rural rich do not show much difference in the quantity consumed of each of these two commodities. The relative importance of a given commodity, such as cereals in Brazil, to urban versus rural consumers may be reversed between the poor and the rich (table 18).

Table 15--Relative prices of bread and wheat imports in selected developing countries

Ratio of price of bread to price of rice in 1980	Country	Average rise in wheat imports from 1961-65 to 1979-81
		Kilograms per capita
0.00 to 0.49	Boliva, Egypt, Iraq, Mexico, Sudan, Tanzania, Turkey	25
0.50 to 1.49	Brazil, Hong Kong, Ivory Coast, Korea, Pakistan, Panama, Sri Lanka, Zambia	10
1.50 or more	Burma, Cameroon, Costa Rica, Liberia, Philippines, Rwanda	3

Source: (5).

Table 16--Percentage of population living in urban areas

Region	1960	1980	2000
		Percent	
World	33.9	41.1	51.2
Developed countries	60.2	71.3	79.4
Developing countries	22.0	30.8	43.8
Africa	18.4	28.9	42.4
East Asia	19.3	27.8	41.4
South Asia	18.4	24.8	37.1
Latin America	49.1	65.4	75.7

Source: (11).

Table 17--Food consumption patterns in rural and urabn areas of Tunisia and Brazil

Food group	Tunisia (1975)			Southern Brazil (1974/75)		
	Rural areas	Urban areas	Major cities	Rural areas	Urban areas	Major cities
	Calories per person per day					
Cereals	1,662	1,307	1,129	1,057	910	897
Trad. staples	1,250	498	222	637	405	431
Bread and wheat flour	246	607	764	405	426	434
Roots and tubers	24	40	40	183	101	75
Vegetables	62	87	80	21	23	28
Fruits	34	34	35	33	39	46
Meat	42	63	90	178	214	227
Fish	3	11	14	8	12	8
Milk	68	50	108	139	120	152
Oils and fats	400	447	431	252	307	328

Source: (12).

The above findings may imply that the urban-rural differences are due primarily to resource constraints. Another interpretation may be that higher mobility of the rural rich and frequent interaction with urban areas make their consumption behavior less dependent on where they reside. Irrespective of the interpretation, however, the findings further amplify the need for income-specific analyses of changes in consumption patterns to derive better estimates of the impact of commodity-specific policies on the composition of demand.

Demand for Feed Grains

Rapidly increasing demand for feed grains is likely to be the most important source of change in future demand patterns in developing countries. Although still at a low level in many

Table 18--Rural and urban consumption patterns for poor and rich in selected countries

Country and commodity	Poor		Rich	
	Urban	Rural	Urban	Rural
	Percent of total calories			
Brazil:				
Cereals	34.7	27.9	34.8	37.0
Rice	19.6	15.1	16.8	17.9
Maize	3.3	8.3	1.2	5.4
Wheat	8.3	1.9	10.7	3.3
Root crops	16.9	24.6	3.8	8.3
Sugar	13.5	11.9	13.3	12.4
Vegetables	.6	.5	1.5	.9
Fruits	1.3	1.0	3.2	2.0
Meat and fish	8.1	6.5	11.5	9.5
Dairy products	2.9	2.8	8.9	8.0
Oil and fats	9.0	5.2	14.8	11.9
Thailand:				
Cereals	80.7	93.4	55.9	67.9
Rice	70.0	91.2	44.0	56.1
Meat and fish	7.0	3.7	14.5	11.8
Dairy and eggs	1.5	.2	3.9	2.9
Oils and fats	3.0	.6	5.2	4.6
Fruits and nuts	.6	.1	4.1	3.1
Vegetables	1.9	1.0	4.1	3.1
Sugar	2.6	.8	3.8	3.7
	Kg per capita per month			
Indonesia:				
Rice	.8	.5	2.2	3.3
Cassava	.07	.5	.1	.8
Sugar	.1	.4	3.6	23.4
Vegetables	.2	.2	.9	4.9
Beef and Buffalo meat	0	.001	.1	.6
Mutton and Lamb	0	.007	.1	
Pork	0	.001	.02	.07
Poultry	0	0	.2	.1
Pakistan:				
Wheat	9.9	12.2	9.2	17.1
Rice	.7	.8	1.7	1.7
Potatoes	.9	.7	.9	102.0
Sugar	.8	.3	1.4	1.6
Beef	.5	.2	.5	.7
Mutton	.06	.03	.9	.5
Poultry	0	.02	.3	.2

Sources: (25,32).

developing countries, large income elasticities (table 19) signify large future increases in demand, particularly in higher income developing countries and centrally planned economies with large economic growth. For developing countries as a whole, Paulino projects that feed grain consumption will grow at an annual rate of 4.6 percent, compared with 2.1 percent for food grain (table 20) (11). The rate of growth in feed grain consumption is expected to be largest in North Africa and the Middle East, while the projected rate of growth in food grain consumption is highest in Sub-Saharan Africa.

The differential growth rates will result in a rapidly increasing importance of feed as a source of grain use. It is projected that feed will account for about one-fourth of all cereals consumed in the developing countries by year 2000, up from 16 percent in 1980. This is a dramatic increase that is likely to put a very significant burden on the supply capacity in higher income developing countries. If domestic supply is unable to keep up, rapid increases in import demand are likely to occur. Such increases have already occurred for many of the high-income developing countries in the Middle East and elsewhere.

As illustrated by the high-income elasticities of demand, the rate of growth in feed grain is strongly correlated with income growth (table 21). The demand for feed grain is derived from the demand for livestock products. Substitutions among types of livestock toward poultry and pig meat tend to amplify the importance of grain relative to other feeds and, thus, further increase feed grain demands. It may be expected that efforts to increase yields in dairy production and expand herd and flock sizes of pig and poultry production units will result in

Table 19--Income elasticities of demand for cereals used for food and feed 1/

Region	Countries	Total demand 2/	Food	Feed
Developing economies	90	0.20	0.14	0.74
Africa	37	-.11	.00	.94
Latin America	24	.36	.18	.74
Near East	14	.26	.17	.39
Asia and Far East	15	.17	.20	1.32
Developed economies	34	.35	-.06	.53
Market	26	.17	.03	.14
Centrally planned	8	.37	-.12	.77

1/ Inocme elasticities have been estimated from the equation e = [(I) - N)/y], where the numerator is the annual rate of growth in per capita demand and y is the per capita GDP growth rate.
2/ Total demand also includes residual uses such as industrial, seed, and waste.
Source: (33)

Table 20--Growth in cereal consumption for food and feed grains

Region	Average annual growth rate				Share of total for feed		
	Food		Feed				
	1966-80	1980-2000	1966-80	1980-2000	1966-70	1980	2000
			Percent				
Developing economies	3.1	2.1	4.6	4.6	14.0	16.0	23.0
Asia	3.0	1.9	4.2	4.4	11.0	12.0	17.0
North Africa and Middle East	3.6	2.5	4.8	6.1	24.0	26.0	39.0
Sub-Saharan Africa	2.6	3.5	3.1	5.5	6.0	6.0	9.0
Latin America	3.3	2.3	5.0	4.0	34.0	40.0	47.0

Source: (18).

an increasing dependence on grains. On the other hand, research, breeding, selection, and improved management practices are likely to increase feed efficiency. The net result is likely to be rapidly increasing feed grain demands in countries with high rates of growth in incomes and livestock production.

To further analyze the development of feed grain demands in high-income developing countries with high rates of economic growth, data for 1961-85 were analyzed for Brazil, Korea, Philippines, and Taiwan. The growth in feed grain demand in response to income growth is impressive and much larger than growth in food grain demand for all four countries (figs. 2-5).

In addition to providing a visual image of the relationship, attempts were made to statistically test the hypothesis advanced by Mellor and Johnston that at some income level, rapidly increasing demand for feed will result in an inflection point in the Engel curve (total consumption function) for cereals (16). The statistical approaches used were inappropriate for such testing and lack of time did not permit more appropriate approaches to be applied. Instead, as a first approximation, "free-hand" curves were drawn (figs. 2-5). Based on this approach, it appears that rapid increases in feed grain demand result in increasing marginal propensities to consume cereals at some income level. Formal statistical testing is needed to determine whether an inflection point is present in the consumption functions for Brazil, Korea, and Taiwan. However, the graphs shown in figures 2-5 clearly illustrate the potential magnitude of the increase in cereals demand in response to income growth in higher income developing countries.

Table 21--Estimated annual growth rate in the consumption of feed and livestock products in 104 developing countries.

Item	Countries	Percentage of population in 1977	Growth rate	
			Livestock products	feed
			Percent	
Level of per capita income, 1980:				
Less than $250	32	52	2.43	2.62
$250-$499	20	21	3.51	4.59
$500-$1,249	29	13	3.99	5.82
$1,250 or more	23	15	3.60	4.98
Total	104	100	3.36	4.63
1961-80 growth rate of--				
Per capita income				
Less than 1.0 percent	30	16	1.76	2.73
1.-2.9 percent	36	49	3.02	4.02
3.-4.9 percent	20	13	3.47	4.56
5. percent or more	8	22	4.91	6.02
Total	104	100	3.36	4.63
Livestock output:				
Less than 1.0 percent	13	5	-0.01	0.83
1. - 2.9 percent	23	15	1.81	3.16
3. - 4.9 percent	44	62	3.68	4.09
5. percent or more	24	18	5.92	7.74
Total	104	100	3.36	4.63

Source: (22)

Figure 2

Annual per capita cereal consumption and per capita real GNP (1970 cruzeiros), Brazil, 1961-85

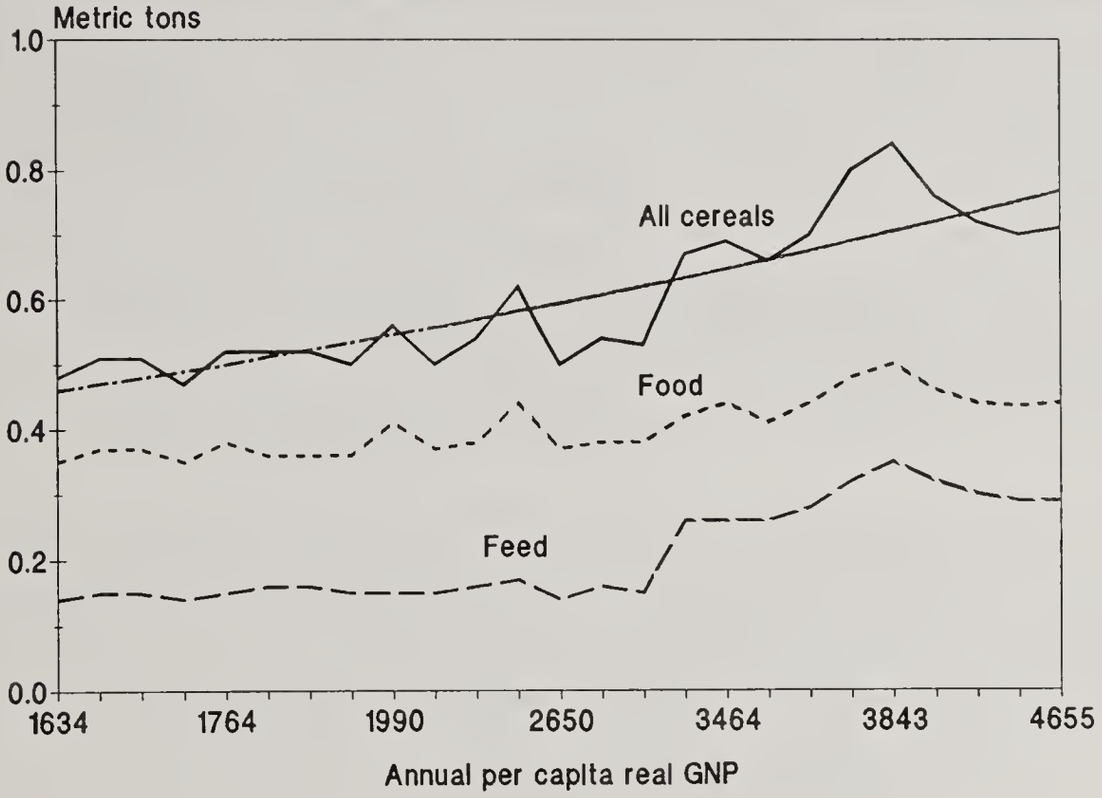


Figure 3

Annual per capita cereal consumption and real GNP 1000's (1975 won), Korea, 1961-85

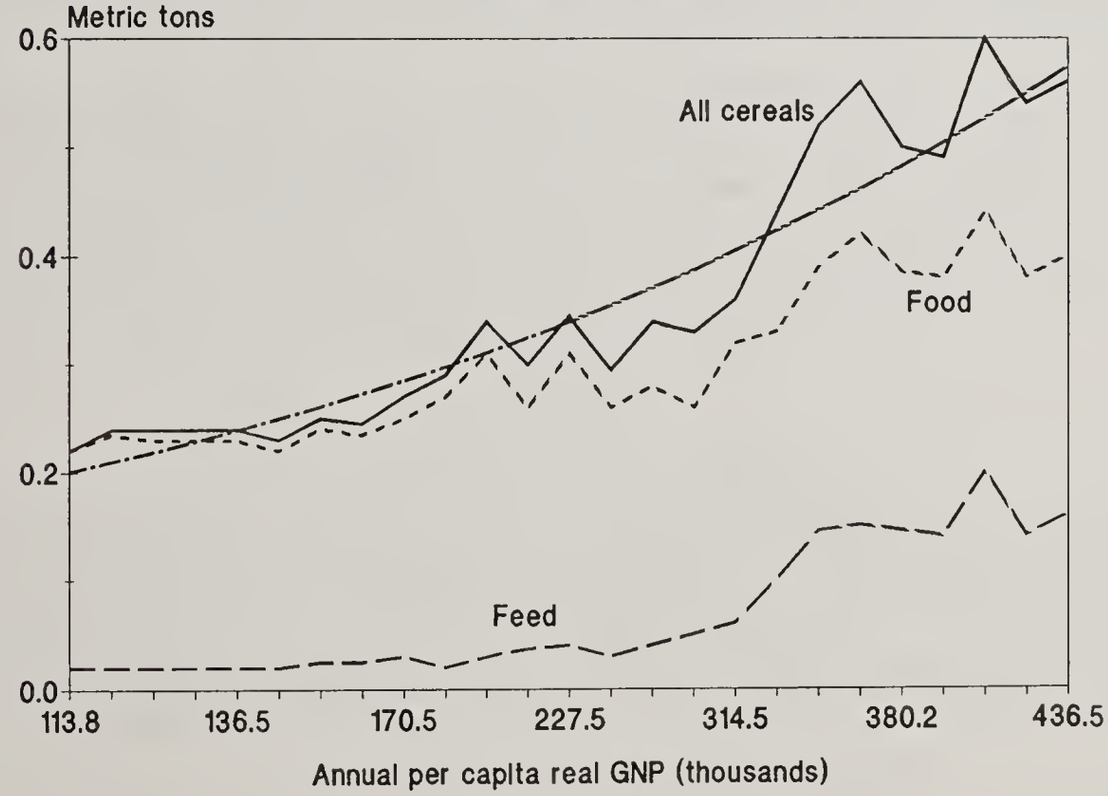


Figure 4

Annual per capita cereal consumption and per capita real GNP (1972 pesos), Philippines, 1961-85

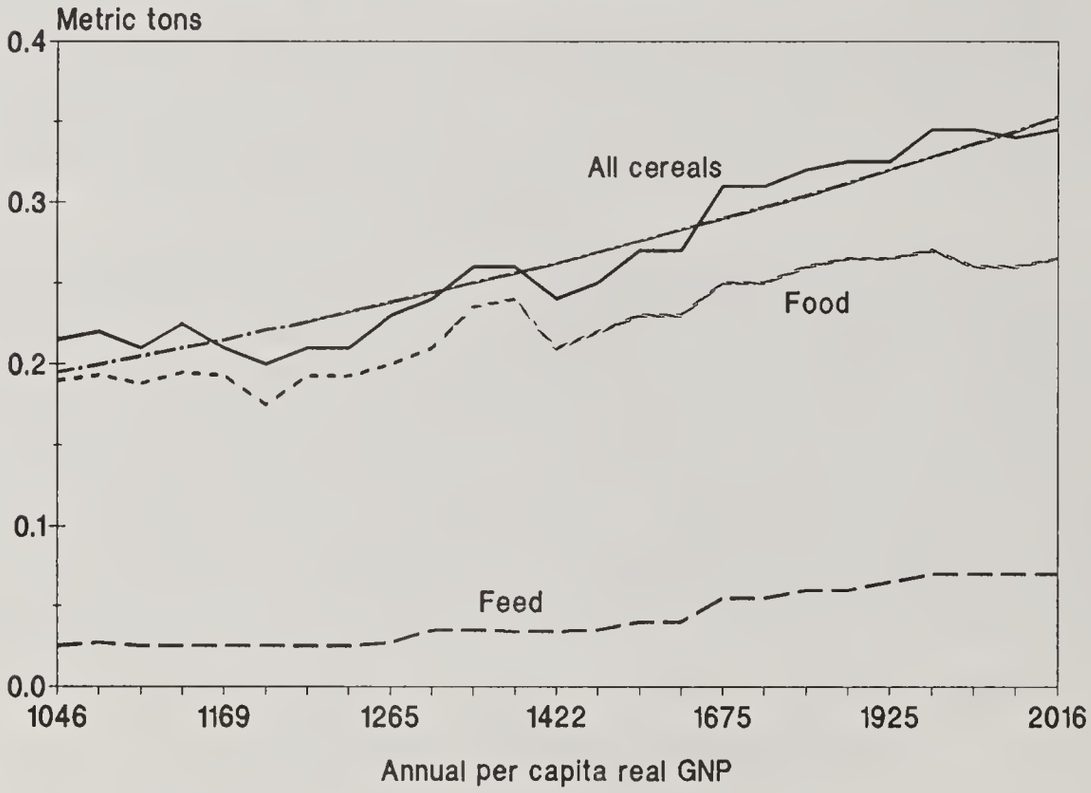
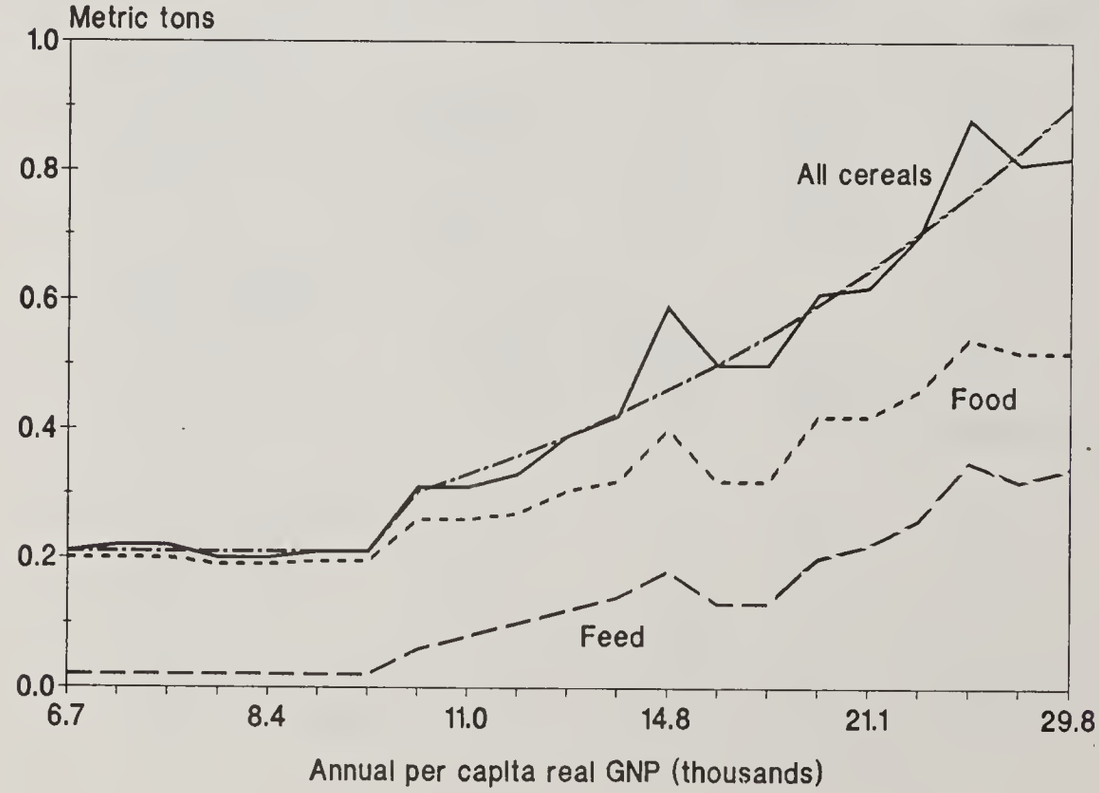


Figure 5

Annual per capita cereal consumption and real GNP (1976 new dollars), Taiwan, 1961-82



Substitution Among Food Grains In Africa

We are currently witnessing a widespread and rapid rate of substitution among cereals in the African diet. A continuation will result in very significant changes in the composition of cereals demand and corresponding repercussions for production and foreign trade. Table 22 illustrates these changes in the consumption pattern for Africa. As a general rule, rice and wheat consumption increases at a rapid rate, while the consumption of coarse grains and roots and tubers--the traditional staples in Africa--decreases. The importance of rice in the diet increased from 6 to 9 percent (a 50-percent increase) in less than 20 years, while sorghum dropped from 16 to 12 percent. Annual growth rates in west Africa were about -2 percent for sorghum and millet, close to zero for maize, and 5 and 8 percent for rice and wheat, respectively. The rates of growth for rice and wheat in Nigeria (the most important economy of the region) were about 11 and 15 percent, respectively, double the region's growth rates (table 23). Rice and wheat are now responsible for more than 25 percent of total cereal food consumed in west Africa, compared with 14 percent 20 years ago (table 24). However, west Africa only accounts for 8 percent of cereal production.

The natural environments in most west African countries are not favorable for the production of wheat and rice. Virtually all the wheat and a large share of the increase in rice consumption are imported. Although efforts to expand rice production through irrigation and other technological change could accelerate its growth rate, the costs involved in expanding rice production at the rate of the current consumption increase are likely to be extremely high. Import requirements are likely to continue to increase. Whether they will be converted to effective import demand will depend on the foreign exchange situation, but it is likely that a large part of the import requirements will have to continue to be met by food aid.

Four factors are expected to be of principal importance in determining future demand patterns for cereals in west Africa: 1) income changes, 2) relative prices, 3) rate of urbanization, and 4) opportunity costs of women's time. As shown in table 25, income elasticities for rice and wheat are close to 1 for the Sahel, between 0.65 and 0.87 for west Africa, and 0.1 for millet in both areas. Thus, it is very clear that income increases are associated with large increases in the demand for rice and wheat but only very small increases in the demand for millet.

Income growth in most of west Africa is not expected to be large over the next decade. Relative prices appear to have changed in favor of rice and wheat during the past 10 years, although not for all countries in the region (table 26 and fig. 6). Reliable direct and cross-price elasticities for food grains are not available for west Africa, but in view of the large income elasticities, they may be expected to be large. The effect of the other two factors--urbanization and changes in the opportunity cost of women's time--is unknown. Research aimed at the estimation of the effects of each of the four, and possibly other, factors on the demand for the various cereals is urgently needed.

Summary of Implication for Future Production and Trade

Data presented in this paper confirm the strong relationship between consumption patterns and incomes both at the national and household level. Therefore, the implications of income growth for demand and trade depend heavily on the distribution of the growth among income strata within a country and among countries with different income levels. During the past 10 years, the difference in the consumption patterns of low- and high-income developing countries has increased, and average figures for developing countries are becoming less useful for the projection of furture demand patterns.

This issue is particularly pronounced in the future demand for livestock products and feed grains. Most developing countries are still experiencing relatively large demand increases for staple food. High-income developing countries, however, are rapidly reaching a situation of

low growth in staple food demand but rapidly growing feed grain demand. Continued rapid income growth in these countries is likely to result in strong increases in cereal demand. A large share of the new demand will probably be met by imports and international cereal prices are likely to be affected, although probably not to the extent that the current downward trend in real cereal prices will be halted. Much will depend on future cereal production in USSR, which is in a phase of rapidly increasing consumption of livestock products and feed grains.

Table 22--Consumption of staple foods in Africa

Commodity	1961/65	1978/82
	Percent	
Rice	6	9
Sorghum	16	12
Maize	18	19
Cassava	20	19

Source: (18).

Table 23--Annual growth rates in the production and consumption per capita of major cereals in West Africa and Nigeria

Cereal	West Africa, 1961/65-1979/83		Nigeria, 1961/65-1976/80	
	Production	Consumption	Production	Consumption
		Percent		
Millet	-2.2	-1.7	-2.0	1.9
Sorghum	-3.3	-2.3	-3.7	-1.4
Maize	-.8	.4	-.6	1.9
Rice	2.4	4.5	3.2	10.7
Wheat	--	7.7	--	14.7

- - = Not available.
Sources: (8,9,10).

Table 24--Share of rice and wheat in total cereal consumption and production, Sahel and West Africa

Country	Share of consumption		Share of production,
	1961-65	1979-83	1979-83
		Percent	
Burkina Faso	4	7	2
Cape Verde	16	40	0
Chad	4	11	6
Gambia	44	57	35
Mali	12	20	11
Mauritania	18	66	21
Niger	2	9	2
Senegal	45	52	12
Sahel	13	22	6
West Africa	14	24	8

Source: (10).

High-income developing countries that choose to restrict cereal imports may be faced with real price increases. The implications may be severe for low-income consumers who spend a large share of their budget on cereals for direct consumption. The competition between poor cereal consumers and rich consumers of grain-fed livestock may become an important policy issue.

Price elasticities for most foods are relatively high among the poor. This implies that price policy may be effective in altering consumption patterns among that group. Since low-income households frequently consume close to the subsistence level, price policy for food should be handled with extreme care to avoid severe hardships among consumers. On the other hand, the ability of the poor to cope with increases in the price of individual foods appears to be greater than previously believed, as reflected in relatively high substitution effects of price changes.

Table 25--Income elasticities of demand for millet, maize, rice, and wheat in the Sahel and West Africa 1/

Crop	Sahel	West Africa
Millet	0.15	0.09
Maize	.46	.15
Rice	.93	.65
Wheat	.92	.87

1/ Estimated from annual time-series data, 1965-79.
Source: (11).

Table 26--Ratio of wheat to coarse grains prices in major urban markets in Francophone West Africa, 1969-83
(5-year averages of annual ratios of per kilogram prices)

Year	Ratio of world prices of wheat and sorghum 1/	Bread to--		
		Maize ratio, Ivory Coast 2/	Sorghum ratio, Burkino Faso 3/	Millet ratio, Senegal 4/
1969-73	1.20	2.86	1.92	0.84
1974-78	1.26	2.03	1.75	1.66
1979-83	1.25	1.55	1.33	1.74
Average annual percentage change 5/	.4	Percent -6.0	-3.6	+7.6

1/ World prices are for U.S. No. 1 Soft Red Winter wheat to U.S. No. 2 Yellow milo, f.o.b. gulf ports from World Bank, "Commodity Trade and Price Trends," 1983/84 edition.
2/ Averages from Treichville and Adjame markets, from France, Ministere des Relations Exterieures (1983). Data from 1974 and 1975 are missing.
3/ Averages from Ouagadougou Markets from Haggblade (1984). Data from 1969 to 1971, 1982, and 1983 are missing.
4/ Averages from Dakar Markets from Jammeh (1984).
5/ Annual percentage change between 5-year averages based on a 10-year interval between midpoints.
Source: (8).

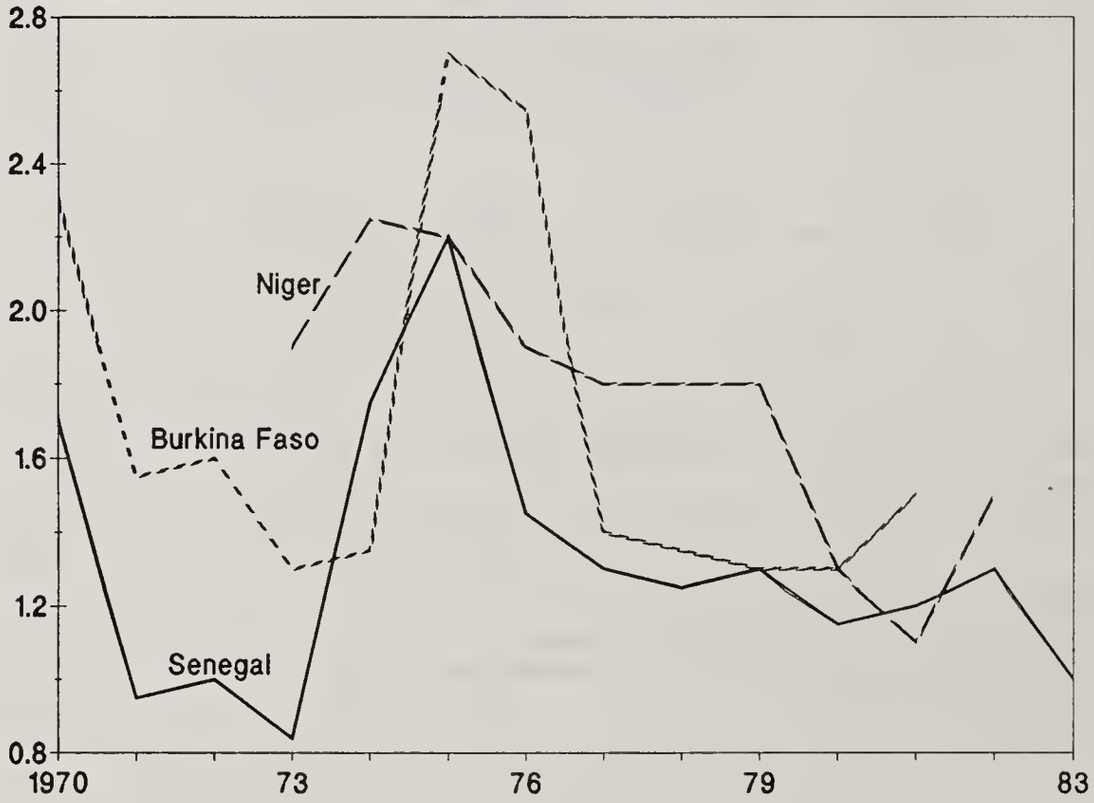
Rapid substitution of wheat and rice for sorghum, millet, and maize in parts of Africa is a topic that deserves serious attention. More research is urgently needed to explain the relative contribution of changes in incomes, relative prices, urbanization, opportunity costs of women's time, and other factors, in order to assist in the design of appropriate policies. A continuation of the current rate of substitution is likely to have very serious implications for import demand. As long as increased demand is met by concessional imports, foreign exchange implications may not be severe. Pending more research, the effect of reduced imports and higher prices for wheat and rice on domestic demand and real incomes of the poor is unclear, not to mention the repercussions for political stability. It is possible that current developments are creating long-term structural changes in the consumption patterns, which will not be easily reversed in response to changes in relative prices. This also implies that the demand for sorghum, millet, and maize is unlikely to respond greatly to reduced prices brought about by domestic production expansions. An early indication of such a situation is presented by relatively large surpluses of maize in Malawi, Kenya, and Zimbabwe at prices below export parity and attempts to barter these surplus for imported wheat and rice.

If cereal substitution is at least in part irreversible, rather than merely a response to changes in relative prices, opportunities for changes in the production patterns should be explored.

Experience to date indicates that massive expansions of rice production in Africa, excluding those areas currently in rice, generally require very large investments. Futhermore, efforts to develop or adapt high-yielding rice varieties have not been very successful, and production costs are generally large. Although prospects may not be bright, further exploration is needed on this matter.

Figure 6

Ratios of rice to millet/sorghum retail prices, selected West African countries



REFERENCES

(1) Alderman, Harold. The Effect of Food Price and Income Changes on the Acquisition of Food by Low-Income Households, International Food Policy Research Institute, Washington, DC, 1986.

(2) Alderman, Harold, and Joachim von Braun. The Effects of the Egyptian Food Ration and Subsidy System on Income Distribution and Consumption. Research Report 45. International Food Policy Research Institute, Washington, DC, 1984.

(3) Blanford, David. "Changes in Food Consumption Patterns in the OECD Area," European Review of Agricultural Economics, Vol. 11, 1984, pp. 43-65.

(4) Byerlee, Derek. "Avoiding the Wheat Trap: How Inappropriate Policies Change Dietary Habits," Ceres, 1985, pp. 20-25.

(5) ____. The Increasing Role of Wheat Consumption and Imports in the Developing World. CIMMYT Economics Program Working Paper 05/83. Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico, 1983.

(6) Calegar, Geraldo M., and Schuh, Edward. "Costs, Benefits, and Food Consumption Impact of the Brazilian Wheat Policy", Forthcoming Research Report, International Food Policy Research Institute, Washington, DC.

(7) Centro Internacional de Mejoramiento de Maiz y Trigo. CIMMYT Maize Facts and Trends. Report Two: An Analysis of Changes in Third World Food and Feed Uses of Maize. Mexico, 1984.

(8) Delgado, Christopher L. "The Influence of Relative Prices on the Substitution of Imported for Domestic Cereals in West Africa: Survey of the Evidence," paper prepared for the 1985 internal project workshop on The Changing Role of Coarse Grains in SAT West Africa, Ouagadougou, June 25-27, 1985.

(9) _____ and Cornelia P. J. Miller. "Changing Food Patterns in West Africa: Implications for Policy Research." Food Policy, Vol. 10, No. 1, 1985, pp. 55-62.

(10) _____ and Thomas A. Reardon. Policy Issues Raised by Changing Food Patterns in the Sahel. International Food Policy Research Institute, Washington, DC, 1986.

(11) Food and Agriculture Organization of the United Nations. The Fifth World Food Survey. Rome, 1985.

(12) ____. Review of Food Consumption Surveys --1985, FAO Food and Nutrition Paper 35. Rome, 1986.

(13) ____. "Role of Roots, Tubers and Plaintains in Food Securtiy in Sub-Saharan Africa," paper presented at the 11th Session of the Committee on World Food Security, Rome, Italy, Apr. 9-16, 1986.

(14) ____. The State of Food and Agriculture 1984. Agriculture Series 18. Rome, 1985.

(15) Garcia, Marito, and Per Pinstrup-Anderson. "The Pilot Food Price Subsidy Scheme in the Philippines: Impact on Incomes, Food Consumption, and Nutritional Status." Forthcoming research report. International Food Policy Research Institute, Washington, DC, 1984.

(16) Mellor, John W., and Bruce F. Johnston. "The World Food Equation: Interrelations Among Development, Employment, and Food Consumption," Journal of Economic Literature, Vol. 22, 1984, pp. 531-574.

(17) Paulino, Leonardo A. Food in the Third World: Past Trends and Projections to 2000. Research Report 52. International Food Policy Research Institute, Washington, DC, 1986.

(18) Piazza, Alan. Food Consumption and Nutritional Status in the PRC, Boulder and London: Westview Press, 1982.

(19) Pinstrup-Andersen, Per, and Mauricio Jaramillo. The Impact of Technological Change in Rice Production on Food Consumption and Nutrition in North Arcot, India. International Food Policy Research Institute, Washington, DC, 1986.

(20) Rohrbach, David. Maize Food and Feeding Consumption in the Developing World. CIMMYT Economics Program Working Paper 04/84, Centro Internacional de Mejoramiento de Maiz y Trigo Mexico, 1984.

(21) Sarma, J.S., "Cereal Feed Use in the Third World: Past Trendsand Projections to 1990 and 2000." Forthcoming research report. International Food Policy Research Institute, Washington, DC.

(22) Sarma, J.S., and Patrick Yeung. Livestock Products in the Third World: Past Trends and Projections to 1990 and 2000. Research Report 49. International Food Policy Research Institute, Washington, DC, 1985.

(23) Scobie, Grant M. "Macroeconomic and Trade Implications of Consumer-Oriented Food Subsidies," in Per Pinstrup-Anderson (ed.) Consumer-Oriented Food Subsidies: Costs, Benefits, and Policy Options for Developing Countries. Baltimore: Johns Hopkins Univ. Press (forthcoming).

(24) Trairatvorakul, Prasarn. The Effects on Income Distribution and Nutrition of Alternative Rice Price Policies in Thailand. Research Report 46. International Food Policy Research Institute, Washington, DC, 1984.

(25) U.S. Department of Agriculture. Reference Tables on Rice Supply-Distribution for Individual Countries, Foreign Agriculture Circular 8-86. Jan. 1986.

(26) ____. Reference Tables on Wheat, Corn and Total Coarse Grains Supply-Distribution for Individual Countries. Foreign Agriculture Circular 2-85. Jan. 1981.

(27) ____. Reference Tables on Wheat, Corn and Total Coarse Grains Supply-Distribution for Individual Countries. Foreign Agriculture Circular 4-81. Jan. 1981.

(28) ____. Reference Tables on Rice Supply-Utilization for Individual Countries, Foreign Agriculture Circular 38-80. Dec. 1980.

(29) ____. Reference Tables on Wheat, Corn and Total Coarse Grains Supply-Distribution for Individual Countries. Foreign Agriculture Circular 5-80. Feb. 1980.

(30) ____. Reference Tables on Wheat, Corn and Total Coarse Grains Supply-Distribution for Individual Countries, Foreign Agriculture Circular 9-76. May 1976.

(31) Williamson-Gray, Cheryl. Food Consumption Parameters for Brazil and Their Application to Food Policy. Research Report 32. International Food Policy Research Institute, Washington, DC, 1982.

(32) Yotopoulos, Pan A. "Middle-Income Classes and Food Crises: The 'New' Food-Feed Competition," Economic Development and Cultural Change, Vol. 33, No. 3, 1985, pp. 463-483.

AN ARGENTINE PERSPECITVE ON RECENT AGRICULTURAL TRADE AND POLICY DEVELOPMENT

Lucio Reca [1]

Production

The Argentine postwar production pattern can be summarized in table 1. Argentine grain production was stagnated during the forties and fifties, grew by more than 3.2 percent a year in the sixties and seventies, and grew even faster at 5.8 percent during 1981-85.

Grain production increased faster in Argentina than the rest-of-the-world during 1960-85. Argentine growth rates for oilseeds almost doubled that of the world and it was 40 percent higher for the grains (table 2).

The postwar Argentine and world patterns of grain and oilseed trade can be summarized as follows:

- o Exports grew faster than production both in Argentina and the rest-of-the-world, implying the increasing importance of trade for these items.

- o Argentine exports increased faster than those of the rest-of-the-world. Argentina increased its market share for wheat, oils, and feed grains during 1960-85.

World exports of wheat, feed grains, and oilseeds have virtually stagnated at approximately 200 million tons since 1980. Production has continued to grow, increasing 100 million tons between 1980-85. An imbalance between production and consumption growth has lead to an

Table 1--Argentine grains and oilseed production and growth rate

Year	Production	Average annual growth rate
	Million tons	Percent
1959-61	16.0	- -
1969-71	22.3	3.4
1979-81	30.5	3.2
1984-86	40.4	5.8

Source: USDA.

Table 2--Argentine agricultural exports and annual growth rate of exports for selected 3-year periods

Year	Exports			Growth rates		
	Grains	Oils	Oilseed by products	Grains	Oils	Oilseed by products
	- - - -Million Tons- - - -			- - - - Percent - - - - - -		
1959-61	5.25	0.27	0.76	- -	- -	- -
1969-71	9.28	.29	.92	5.9	0.8	1.9
1979-81	16.83	.65	1.62	6.1	8.4	5.8
1984-86	20.18	1.38	4.06	3.7	16.2	20.1
1985-60	- -	- -	- -	5.5	6.7	6.9

- - = Not available.
Source: USDA.

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enormous accumulation of stocks and a sharp decrease in the international prices of grains. The accumulation of stocks in the United States and the Europeon Community (EC) coincides with domestic policies that support prices received by farmers and that tend to isolate them from the rest-of-the-world market.

Growth of Grain Production and Trade

The rapid growth in world grain trade can be analyzed in terms of factors affecting supply and demand. Rapid technological change and the implementation of domestic policies that tend to protect farmers from world market forces are the most important elements explaining supply response. Both factors have become increasingly important since World War II, particularly in the EC and North America.

New technological developments allowed countries that had the political will and agricultural infrastructure to obtain self-sufficiency by using domestic policies that isolated their farmers from world market conditions. By introducing "artificial" input/output price ratios, they encouraged intensification of agricultural production. This phenomenon, concentrated in the developing countries at the beginning of the period, spread to many developing countries in the sixties and seventies with the "green revolution" and more recently to China.

Argentina also benefited from technological developments. More than 75 percent of its production increases in the past 25 years were due to productivity increases. Only 25 percent was due to expansion in planted area. Argentina, unlike other exporters, didn't use protectionist agricultural policies. Indeed, Argentine farmers have been faced with export taxes and an overvalued exchange rate for the past 25 years. Thus, increases in our grain production and market shares are based on the competitiveness and low cost of agricultural production in Argentina. This competitiveness has resulted from the quality of our natural and human resources and the technological improvements that farmers have adopted over this period.

The overall economic environment, political conditions, and agricultural policies have induced Argentine farmers to build a very efficient production system, which is able to cope with instability, changes in relative prices, and external competition. Improved seed use, crop management, and proper use of machinery have been preferred to intensive use of chemicals, determining a "less risk-less intensive" technological pattern. This has not lead to as high yields as those obtained in the EC and United States, but it is more appropriate for Argentine farmers, given their economic conditions.

On the demand side, sustained global economic growth generated dramatic increases in consumption in the sixties and seventies. The global economic problems encountered in the midseventies were compensated for by the emergence of some "new rich" countries (mainly oil exporters and southeast Asian countries) and the "easy money" period that followed the oil crisis. Things changed sharply in the eighties with the "debt crisis" that exploded in 1982, the increase in real and nominal interest rates, and the global recession that followed.

Present Situation and Perspectives for the World Grain Markets

The current situation is dramatically different from the one prevailing in the past two or three decades. The world market is affected by an excess of supply, concentrated in the developed countries, and a much more wide spread demand, concentrated in developing countries and in the centrally planned economies. Many of the recently emerging importing countries are countries with a state import agency where decisions to buy grain in the market are tied to political factors.

One of the main economic characteristics of the grain market is that supply and demand levels are much more dependent on domestic policies than on market conditions. Protectionist agricultural policies, mainly in the United States and EC, have isolated farmers' decisions to produce from market signals, thus leading to oversupply.

The decline in export prices is another consequence of the economic policies undertaken by the United States and EC, affecting not only countries responsible to this situation but others who adjust domestic prices to market conditions (Argentina and Australia). Because Argentina does do not offer credit and subsidies, its net export prices of grains decreased more than those in the United States. Wheat f.o.b. prices dropped 29 percent from U.S. gulf ports during 1978-86, compared with 40 percent in Buenos Aires. Similar price changes (34 percent to 41 percent) occurred for corn.

Whether this situation will change depends to a large extent on the evolution of domestic agricultural policies in the EC and the United States, on demand growth, and on the outcome of the new round of the General Agreement on Tariffs and Trade (GATT) negotiations. The Common Agricultural Policy (CAP) has two unintended consequences that threaten its continuity. These are budgetary pressures and negative effects on foreign policy. They have caused the more influential members of the Agricultural Commission to search for new policy options to reduce excess supply, while maintaining farmers' incomes. They are currently considering expanding the quota system already imposed on milk production, gradual reduction of prices, taxation of inputs, development of alternative uses for grains (such as ethanol production), and creating a conservation reserve.

The reduction in agricultural prices last year was supposed to be a signal of this new direction. However, it doesn't seem adequate to counterbalance productivity increases that are still moving production upward.

It is difficult to forecast changes in the CAP in the short run. The "subsidies war" between the United States and EC is still worsening, driving prices down to levels never before seen ($64 a ton for wheat).

In the United States, the new agricultural law passed in 1985 will frame agricultural policy over the next few years, even if the new democratic majority in Congress will make some changes. The 1985 Farm Act establishes mechanisms that allows the United States to transfer adjustment in production to foreign markets. By sharply reducing the loan rate that represented a floor price for international prices of wheat and corn and implementing direct subsidies to exports (payment-in-kind) in addition to the previous indirect subsidies (soft credits), the United States is inducing to large decrease in world market prices, while attempting to recover her market share and, at the same time, reducing her public stocks of grains. These agricultural policy measures are reinforced by a depreciation of the U.S. dollar and a decrease in interest rates that will also help to increase the competitiveness of U.S. exports.

There may be some positive effects of these changes in the short run even if the everchanging level of stocks do not lead to a quick recovery of prices. There is nothing in the law, however, to induce structural changes in the incentives system. Even if loan prices decline and adjust in the future, returns to farmers won't adjust because target prices are kept constant. The difference between target prices and loan rates are paid for by "deficiency payments" that clearly represent a direct subsidy to farmers. The only elements currently designed to reduce production are the conservation reserve and set-aside programs, which are established on a year-to-year basis and could be eliminated quickly.

Recent program changes made by Congress and the sharp increases in the cost of these programs could induce more changes. However, farmers' organizations political power is considerable. At present, propositions for adjustments vary from increasing liberalization by

decreasing target prices and compensating small farmers via an income subsidy to enhancing protectionism by reinforcing the export subsidies by expanding the "marketing loan" system.

Demand recovery appears in the short run to be the major factor leading to an improvement in grain market conditions. Changes that occurred in some macroeconomic variables could favor this process. The main global factors are decreases in the interest rate, depreciation of the U.S. dollar, renegotiation of debt repayment terms in some countries, decline in worldwide inflation, and the moderate recovery of some developed economies.

This set of conditions may strengthen economic development in some newly industrialized countries (NIC's) and induces it in other developing countries, especially in Latin America and Asia where there is a high-demand potential for food because "there is the need and not yet the income." Recent developments quickly increased demand for beef, dairy, and other foodstuffs in Brazil and lead to a 30- to 40-percent increase in meat prices in the world markets.[2]

Finally, the GATT negotiations that will take place over the next few years may influence world trade and commercial relations among countries. Nothing spectacular could emerge from these negotiations in the short run. The eventual effects would only appear in the long run. I strongly believe that in the longer run negotiations will help convince the EC and the United States to adjust their domestic policies. The simple fact of having to included agriculture in the negotiations, for the first time in GATT's history, suggests that there is a disposition to negotiate.

In this same area, there is no doubt that the creation of the "fair traders in agriculture" or "group of 14," lead by Argentina, Australia, and other agricultural countries that do not subsidize exports, gives much better bargaining power to countries interested in liberalizing agricultural trade.

Impacts of the Market Situation on the Argentine Economy

Many factors have had serious impact on the Argentine economy in the 1980's. Among these factors are the debt service problem which resulted from the change in world conditions, the deteriorating market for commodities, and the resulting implications of these changes for government and farmers' incomes.

Impacts on Total Exports and on External Debt Service

Export price levels of grains and byproducts have a substantial impact on the Argentine economy. This is because agricultural exports constitute the main source of foreign exchange for external debt repayment. Exports of grains and byproducts represented between 38 percent and 58 percent of Argentine total exports since 1980 (table 3).

During the eighties, Argentina experienced only a small increase in the value of agricultural exports in spite of the substantial volume increase. The value of these exports increased only 39 percent, while volume doubled.

The 1986 situation is even worse. The value of exports increased only 5 percent compared with 1980, while the volume increased by 67 percent. The reason for the fall was that 1986 prices were only 63 percent of their 1980 levels.

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[2]There are indications that the green revolution in some Asian countries has reached a peak, and new technologies are not currently available that will permit them to sustain historical growth rates.

It is hard to estimate the implications of the subsidy policies followed by developed countries on the economy of Argentina. This is because the lower agricultural prices (that are consequences of those policies) affect many economic variables. For example, it has been estimated that if the total volume of grains, oils, and byproducts exported in 1985 had been the average price of 1978-80, total export value would have been $7.2 billion instead of the $4.3 billion that resulted from 1985 prices. This difference of $2.9 billion represents more than 50 percent of the external debt service requirements or 66 percent of the value of total imports (table 4).

There is a contradiction in the attitude of the developed countries. On the one hand, their protectionist policies induce a reduction of agricultural prices. On the other hand, developed countries exercise continuous pressure on the developing countries, most of whose foreign income comes from agriculture, to keep current with their external debt payments.

Impact on Fiscal Resources

Grain and byproduct exports in Argentina have been taxed for the past 25 years. This has been an important source of government income (table 5).

The estimated 1986 and 1987 export tax collections are 40 percent and 73 percent less than in 1985, respectively. This was the result of the combined effects of lower prices and reductions in tax rates.

Impact on Farm Income

Considering that the main market for Argentine grain and byproducts is the international market and that domestic policies during recent years have tended to maintain a close association between domestic and international prices, farm income has been a function of:

1. F.o.b. quotations,
2. The effective exchange rate for each product, and
3. Domestic marketing costs.

The decline in external grain prices has induced a decrease in domestic prices, but this decrease has been partially compensated by improvements in the exchange rate for each product (table 6). The domestic price for wheat in 1986 was 23 percent less than the 1980 price, while the f.o.b. quotation was 55 percent lower. The domestic price for corn during the same period was down 20 percent, while the f.o.b. price was down 50 percent. The domestic price for soybeans in 1966 was 10 percent higher than in 1980, while the f.o.b. price was 25 percent lower.

The conclusion is that the impact of the decline in agricultural prices has been much larger for the country's net income than at the farm level. For 1985-86, farmer's net income reached the lowest level in recent history. In other words, the adjustments of domestic marketing policies and of the exchange rate for each product have not been sufficient to maintain farmers' net incomes. This situation was aggravated further in 1985/86 when grain yields were low because of weather conditions.

Conclusions

The present situation in world agricultural markets could well be characterized as economically irrational, politically selfish, and ethically unacceptable.

Table 3--Argentine total exports, exports of grains and byproducts, and the grain/export ratio

Year	Total Exports	Grain and byproducts	
	Million U.S. dollars		Percent
1980	8,021	3,084	38.4
1981	9,143	4,117	45.0
1982	7,624	3,049	40.0
1983	7,836	4,377	55.9
1984	8,107	4,723	58.3
1985	8,397	4,300	51.2
1986 1/	7,000	4,240	46.3

1/ Projection.

Table 4--Argentine exports, imports, and debt-service payments

Item	1983	1984	1985
	Billion U.S. dollars		
Exports	7.84	8.11	8.40
Imports	4.51	4.58	3.90
Debt-service payments	5.40	5.71	5.30

Source: Central Bank of Argentina.

Table 5--Argentine grains and oilseed exports, taxes on exports, and implicit import tax

Year	Export value	Export tax receipts	Average implicit export tax
	- - Billion U.S. dollars - - - - - - -		Percent
1982	3.05	0.34	11.1
1983	4.38	.93	21.1
1984	4.72	.96	20.3
1985	4.30	1.02	23.7
1986 1/	4.24	.61	18.8
1987 1/	3.10	.27	8.6

1/ Projections.

Table 6--Argentine f.o.b. and farm price indices of wheat, corn and soybean1/

Year	Wheat		Corn		Soybean	
	F.o.b.	Farm	F.o.b.	Farm	F.o.b.	Farm
	1980 = 100					
1980	100	100	100	100	100	100
1981	96	93	80	82	103	116
1982	77	108	65	96	92	149
1983	63	101	73	110	89	146
1984	54	88	78	112	104	136
1985	47	73	62	97	77	113
1986	45	77	50	80	75	110

1/ F.o.b. means free on board.
Source: Argentine National Grain Board (JNG).

Countries without comparative advantages but with sufficient economic power produce what could be done more efficiently in many LDC's that depend heavily on agriculture for their economic development. By using protectionist policies, developing countries reduce the possibilities of developing countries paying their external debts and importing goods from the developed world.

From a political point of view, this attitude of the western developed countries shows that "narrow minded short-term nationalistic" objectives largely prevail over the long-run aim of increasing economic and political interdependence between "allies" who need economic development to strengthen democracy. As President Alfonsin says, "there's no democratic stability without economic growth," and Latin American history shows us a lot of examples of this.

Finally, it is absolutely unacceptable from an ethical point of view for large stores of foodstuffs to be kept as stocks in the most developed nations of the world, while millions of people die of hunger every year. Thus, while milk powder is denatured for feeding uses in some countries, people are starving in other countries because they have no food. This clearly shows that the realization of the Malthusian prophecies that were so popular only 15-20 years ago depend more on principles related to human ethics than on man's ability to produce food.

Argentina, like many other countries that do not subsidize their agriculture, is being strongly affected by protectionism and its influence on world markets. Argentina's fair trade policy provides a strong link between domestic and international markets. Thus, local producers must adjust to world price changes. Therefore, Argentina is harmed not only by the direct effects of price reductions on the value of fiscal receipts and returns to farmers, but also by the indirect effects that are discouraging farmers and inducing them to produce less. The adjustment actually taking place in countries like Argentina is not only damaging in the short run, but it is also affecting the possibility of intensifying production and reaching, in the medium run, higher levels of production that potentially exist.

Argentina introduced changes concerning domestic policies that could counterbalance the unfavorable market situation. There are two areas where measures could be taken to improve returns to farmers: taxation policy and the reform of the grain marketing system. The first area would be to substitute a land tax for export taxes. The Argentine Government has already sent a proposal to congress that could be approved next year. The second one would require large investments in infrastructure (railway, ports, and others) and a redefinition of the public sector's responsibilities in this area. The Argentine Government has initiated the studies that are necessary to modify the regulations actually in place, as well as negotiations with international financial institutions that could contribute to these projects.

In the short run, both measures require substantial tradeoffs with global, fiscal, and monetary policies. In June 1985, the Government implemented a very stringent stabilization plan, now known as "The Austral Plan." Two other objectives of this plan were to reduce the huge fiscal deficit and to control inflation by tighting monetary policy. Results have been excellent. Inflation has fallen from 30 to 4 percent a month and the fiscal deficit from 14 to 4 percent of GDP. The cost of such a program is that there is little room to use other economic measures that could affect the basis of the plan.

Domestic agricultural policy is very much linked to global economic policy. The restrictions derived from the later affect the outcome in agriculture. Global economic restrictions result, to a large extent, from the huge external debt.

In the long run, Argentina will surely continue to be an important exporter of grain and take advantage of agriculture as a source of economic development. Recent studies confirm the fact that Argentina's cost of production for the principal crops are much lower than those in

the United States and that agriculture is the most efficient means to generate foreign exchange earnings, a fact frequently overlooked in domestic policy discussions.

Technical and structural changes in the domestic marketing system and in tax policy are the means to guarantee the competitiveness of Argentine agricultural exports in the long run.

TRADE AND DEVELOPMENT, DEVELOPMENT AND TRADE

Mathew Shane [1]

There is an important relationship between trade and economic development and also one between development and trade. The first, highlighted by T. N. Srinivasan, focuses on the impact that trade has on development. There is another analysis, perhaps best put forward by John Mellor, that the driving force of trade, agricultural trade, is income growth. I will briefly discuss the underlying analysis of each and then their relationship to each other. I will only focus on the highlights of these issues, recognizing that many details and refinements will be omitted. My objective is to place this discussion into its overall context.

Trade and Development

Classical trade theory argued that by using trade according to comparative advantage a country can achieve a level of income in excess of what could be achieved with domestic resources alone. Although the neoclassical argument of the gains from trade is clearly the source for much of the argument toward outward as distinct from inward orientation policies, the number of simplifying assumption underlying this analysis precludes this from being more than the starting point for the analysis.[2]

The most serious drawback for our purposes is that the framework is static rather than dynamic and abstracts away from all of the problems facing real economies in the highly uncertain real world that we live in. The discussion of the relationship between trade and development gets us into both issues of intertemporal choice and the issues of market imperfections and uncertainty.

Issues of Dynamics

Development is a dynamic process, the core of which is technical and institutional change leading to increases in standards of living exemplified by rising per capita income. From the classical model, static gains from trade can be achieved under certain conditions. However, can trade be an avenue that induces a pattern of development that leads to a higher rate of growth in income than would occur without trade? Central to this issue is technology and information. Whether one can actually obtain a new long-run equlibrium growth path with higher per capita income growth or just a temporary path with higher growth is not really important here. Although we are just obtaining a set of increases in per capita income rather than in growth, the central issue may be whether one can achieve clearly superior levels of consumption (see report by Lucas (1)).[3]

Suppose that an economy is faced with two investment possibilities: one, the traditional technique and the other a new technique available from the world market. Suppose further that there are scale factors associated with the implementation of the new technology such

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[1]The author is an economist with Agriculture and Trade Analysis Division, Economic Research Service, U.S. Department of Agriculture, Washington, DC.

[2]Nonsatiation, free disposability, the possibility of lump sum transfers, and the existence of a social welfare function are but a few assumptions.

[3]Underscored numbers in parentheses are listed in the References at the end of this article.

that the purchase of this technology in beyond the means of the economy. If finance and trade is not available, an economy can either borrow money to purchase the new technology or joint venture with a group that has access to the new technology.[4] By obtaining this technology, an economy can achieve a present discounted valued consumption stream clearly superior to one without the prospect of technical transfer.

Trade can take place in factors that directly affect production possibilities as well as commodities. Thus, trade and international finance are integral parts of the process of technical change. We can, however, even broaden this further so that the trade process involves not only elements of technical change, but institutional change as well. The setting up of the international research centers is but one example of the transfer of institutional capacity.

The ability to trade under unbiased conditions not only allows for technical and institutional change underlying a dynamic growth process, but also fundamentally alters the dynamic inducements toward future change. Trade not only allows for increases in income and capacity, but it does so under a changed system of relative prices. This change in relative prices, therefore, induces a process of technical change that can be substantially different from that which would occur without trade. Furthermore, the ability to market internationally allows for expanded production capacity beyond what could be used in the domestic economy alone, permitting the exploitation of economies of scale.

The informational efficiency, which unbiased price signals provides, should not be underestimated. Embedded in world prices are signals about returns to investments and production. An unbiased price indicates possibilities for returns based on what the market is willing to accept. Biased prices, which deviate from free trade solution, imply investment returns unrelated to demand factors and the possibilities of surpluses or deficits in the future. The fact that current prices reflect current expectation of conditions and not necessarily those that will exist in the future does not change this. This only points to the need to develop contingency markets to insure against changes in market conditions.

The sixties and seventies were periods when trade by developing countries grew more rapidly than did their per capita incomes. Growth in per capita exports grew at 8-percent per annum, while growth in per capita gross domestic product (GDP) for developing countries grew at 5-percent per annum. Growth in real agricultural trade per capita grew at approximately the same rate as per capita GDP. During the sixties and seventies, developing countries were increasingly taking advantage of both the static and dynamic gains of trade. This pattern has not continued into the eighties.

Although developing countries, on average, pursued policies to increase their openness to world markets, a substantial number of them pursued policies resulting in reduced exposure to world markets. Given the advantages of participating in trade, why would such patterns persist over long periods of time? The analysis of this issue takes us into the subject area of government intervention. The answer lies in the fact that some individuals or groups view reduced exposure to the international market as being in their best interest. They pursue this because there are rents to be obtained from controling access to these markets.

By defining government intervention as any policy or action taken by governments that cause prices to deviate from what would prevail in an unbiased market, we can view the consequences of such intervention on the trade and development process in several ways. One type of government intervention involves a movement of domestic prices away from free trade

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[4]Vernon Ruttan has stressed that the contribution of social scientists as distinct form technical scientists is that the former is concerned with institutional change, while the latter is concerned with technical change (4).

solutions. This involves several possibilities. One involves the movement of prices from world market toward their autarky levels or beyond. It is possible, and there appear to be several empirical instances in which this has occurred, when government intervention has actually led to a situation in which countries become exporters of their "natural import good" and importers of their "natural export good." It is also possible for governments to subsidize exports and generate exports in excess of the free trade solution. Government interventions can clearly distort the trade mix away from an unbiased outcome.

What is the impact of government intervention on growth and development? If under competitive equilibrium assumptions, the unbiased trade solution represents a static global optimal outcome, any deviations from that solution will represent a loss and will likely imply a slower growth outcome. It is possible, however, if there are market imperfections present or if the government has a lower discount of the future than does the private sector, that government intervention could lead to higher growth and development outcomes than would be obtained by an unbiased solution. One only needs to reflect on a situation where the outcome results in higher rates of efficient investment. Higher growth will be generated, but at the cost of current consumption. This solution is efficient, but not Pareto optimal. It appears that government intervention from the perspective of economic development does not necessarily generate an inferior outcome.

Development and Trade

Up to this point, the discussion has focused on issues relating trade to development. These issues relate primarily to the production side of an economy. It is argued, if an economy pursues an outward-oriented unbiased trade policy, that an economy can use the gains from exporting commodities to increase income, consumption, and growth. The related issue looks at the impact that development and growth has on the demand for imports. If export growth drives income growth and development, then income growth and development drive the demand for imports.

How development impacts on the import mix changes over the course of development. We can demonstrate this by focusing on what happens in the food and agricultural sector. In the early stages of development in which many of the low-income developing countries fall, the staples of consumption are largely confined to basic foodstuffs. These would include roots and tubers, coarse grains, and food grains if produced locally or provided on concessionary terms. The income constraint is binding on demand, and the technology constraint is binding on production. Very little trade takes place during this stage. There is, however, a very high-income elasticity of demand for food which can be greater than 1 in some instances. It is this very high-income elasticity that makes these countries potential import markets.

There is an intermediate stage when the dynamics of development drive the dynamics of trade growth. During this stage, large increases in per capita income occur and driven by the high-income elasticities, and a changing composition of the diet from basic staples to food grains to meat, demand for food far outstrips the increases in production. This excess demand is met by increases in imports.

There is a final stage of development when consumption patterns mature. In this stage, the income elasticity for food can become negative. Furthermore, an institutional basis has been developed for generating sustained increases in production through technical change. In this stage, import growth either levels off or declines. In a number of instances, these countries can switch from being importers to exporters when the agro-climatic resource base and political environment is correct.

This pattern is reflected in the empirical trends of developing and industrial countries. The rapid growth in demand for food in the developing countries during the past 20 years has

generally exceeded their capacity to accelerate domestic production. The opposite is true for the industrial countries; demand is growing slower than production (table 1). Thus, these two groups are becoming increasingly dependent on each other. The surpluses produced in the industrial countries are key to meeting the rapidly increasing food needs of the developing countries.

The empirical patterns associated with development are striking. It is the middle- and upper-income developing countries that are the growing markets for agricultural products and not the low-income countries. Underlying the serge in imports is the transition to meat consumption from food grains. The underlying production and use patterns in developing countries implies a much higher import growth demand developing for coarse grains rather than for food grains. This is most notably occurring in the upper-income developing countries rather than the low- and middle-income countries. The increasing use of coarse grains for feed also supports this theory.

Factors related to food demand and its components are driving the system. By using results from cross-section time series data, we found the income-elasticity patterns that generated the import patterns (3). The elasticity for the food grains (wheat and rice) rises rapidly until incomes reach approimately $1,000, and then declines throughout its range, becoming negative at about $3,500. The income elasitcity of meat rises more slowly and has a plateau at approximately 0.8 between incomes of $1,000 and $4,000 and slowly accelerates its decline so that when incomes reach $7,000, it becomes negative. This elasticity for the components of food translates into nonlinear patterns of food consumption per capita, which have increasing and then decreasing per capita patterns for food grains and meats and an overall declining pattern for coarse grains.

Table 1--Consumption and production changes in developing and industrial countries

Item	Change 1961-63 to 1980-82	
	Developing	Industrial
	Percent	
Consumption per capita:		
Food grains	23	1
Coarse grains	20	35
Oilseeds[1/]	10	127
Production per capita:		
Food grains	14	44
Coarse grains	4	74
Oilseeds	66	140

1/ Oilseeds include only soybeans, soybean oil, soybean meal, peanuts, peanut oil, and peanut meal.

Source: (2)

Conclusions

The changing composition of demand as a driving force for import demand extends far beyond the food sector. Development creates demands for an expanded consumption bundle that will outstrip the capacity of an economy to respond, at least in the short run. The relationship between trade and development and development and trade is thus a complementary one. The ability to export and respond to world demand in a way consistent with comparative advantage allows low- and middle-income countries to accelerate their growth and development far beyond what could be obtained in a self-sufficient autarky state. The resulting income growth provides consumption demands that exceed domestic capacity. Since exports are a lead sector, the foreign exchange necessary to respond to changing demand is available. Exports drive development, which drives import demand. It is, therefore, not surprising that the single most important variable in import demand is foreign exchange availability and not income. Income growth, as we have seen, can have both positive and negative effects on import demand, depending on the development stage of a country.

The current world environment in which both trade and income growth are lagging is a very poor environment to stimulate development. Many developing countries, saddled with substantial international debt, are faced with declining per capita incomes for the foreseeable future. Considering the interdependence of the developing and industrial world, solutions must be sought that will allow us to break out of the current low-level world equilibrium.

REFERENCES

(1) Lucas, R. E. "Mechanics of Economic Development," unpublished manuscript, Univ. of Chicago, Dept. of Economics, 1986.

(2) Marks, Suzanne Marie, and Mervin J. Yetley. Global Food Demand Patterns Over Changing Levels of Economic Development. Staff Report No. AGES870910. U.S. Dept. Agr., Econ. Res. Serv., Oct. 1987.

(3) Roe, Terry, Mathew Shane, and De Huu Vo. Price Responsiveness of World Grain Markets: The Influence of Government Intervention on Import Price Elasticity. TB-1720. U.S. Dept. Agr., Econ. Res. Serv., June 1986.

(4) Ruttan, Vernon. "Social Science Knowledge and Institutional Change, "American Journal of Agricultural Economics, Vol. 66, No. 5, Dec. 1984, pp. 549-559.

CIMMYT's ROLE IN WORLD AGRICULTURAL DEVELOPMENT

THE EVOLVING ROLE OF CIMMYT: SOME ISSUES FOR WORLD FOOD AND AGRICULTURE

Don Winkleman[1]

The CGIAR System and History

The Consultive Group on International Agricultural Research (CGIAR) emerged in the early seventies as a consequence of apprehension about food production capacity in developing countries. There was a conviction at that time that the food shortages that were being encountered could be ameliorated through a concerted international effort. The model for that international effort was Centro Internacional De Mejoramiento de Maize y Trigo (CIMMYT's) earlier work in Mexico and International Rice Research Institute (IRRI's) with rice in the Philippines. CIMMYT's started under the auspices of the Rockefeller Foundation in the midforties. It was the success of those efforts through the fifties and sixties, (from Mexico to North Africa, India, and Pakistan) that gave the organizers of the system the faith that this model might be a useful way to organize agricultural research focused on other problems. The system was thus born.

It was recently reafirmed that the major focus of the system is to help increase developing countries' (LDC) production of staple foods. There is a center that focuses on agricultural policy issues, International Food Policy Research Institute (IFPRI), and another that focuses on management issues in agricultural research. The budget currently is around $180-$185 million a year. The system has not grown in real terms over the past 6 years. We are becoming even more conscious of our need to be efficient, and because of this, we are achieving some efficiencies in the organization of our activities. There are approximately 40-45 donor countries. The number varies from year to year, depending on each countries capacity to give. None of our current donors are foundations.

The system has been able to make fairly significant contributions to agriculture around the world without any sort of a formal structure. We deal directly with national governments and develop working relationships. The system is abstract, fragile, and loose knit. That is not to say that the CGIAR system, per se, has no international status. It really is an idea that works largely because of the commitment of the people who are associated with it and because it turns out to be a very efficient and effective way to pursue improved technologies for developing countries.

CIMMYT's Structure

CIMMYT's staff is divided into two parts: a core staff that is directly funded through the operations of the CGIAR, and a staff that is associated with special projects. There are slightly more than 100 senior staff members, of which 85 are funded under the auspices of the CGIAR. We deal with CGIAR for those positions through the Technical Advisory Committee (TAC). Our regular budget was approximately $20 million for 1986. In addition, $5 million came from special project funding. The staff of 85 is distributed with 34 in the maize program, 29 in the wheat program, 7 in the economics program, and the remainding 15 in experiment station management, communications, computers, laboratories, accountant, and financial advisors.

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[1]Director General of CIMMYT. Parts of this paper are drawn from "CIMMYT Research: Extending the Gains", presented at the Ceremony Celebrating the 20th Anniversary of CIMMYT.

The Hallmarks of the CIMMYT

The essential elements are on field work, on the importance of direct researcher involvement, and on a pragmatic basis, with the needs of farmer-clients and the benefits and obligations of an open association with the worldwide network of practitioners sharing the same principles. Throughout our history, we have played our role in concert with national research programs. These programs are CIMMYT's clients. We see ourselves as agents for complementing their work, thereby facilitating their efforts to serve their own clients--the farmers. The center is recognized and treated as being above politics. This turns out to be enormously important. Over the years, it has always responded to the needs of national programs without limitations imposed by its individual donors. National programs have long recognized that status and have no reservations about sharing through CIMMYT nor about CIMMYT's willingness to share with them. This even handedness is a continuing CIMMYT hallmark, and the resulting trust is one of our most valued assets. Like others in the CGIAR system, we see clear advantages in long horizons and sharp focus. The two combined bring patience and care in the pursuit of well defined research themes. That blend contributes notably to CIMMYT's success as it did to the success of our predecessor organization. Our evolution continues to be conditioned by a commitment to multidisciplinary research. We see advantage in combining disciplines, practice this ourselves, and advocate it for national programs.

CIMMYT's Products

We produce intermediate goods that are made available to national programs. National programs fashion finished technologies for farmers. We produce germplasm (our primary product), research procedures, training, counseling, and information.

CIMMYT's Future

We recognize the importance of our work given the current emphasis on productivity. Previously when you read statements related to the CGIAR system, it was production that was emphasized. We also recognize that growing international trade in agricultural commodities has important implications for national program research. We also see the importance and the difficulty in identifying comparative advantage in today's open economies. Because financial flows influence exchange rates, it is difficult to identify comparative advantage. This reflects in the national programs ability to identify where their interest lie and thus to determine what it is that they most want from us. We see growing strength in some national programs and recognize that this presents the CGIAR system with new opportunities. CIMMYT and IRRI have discussed ways in which tasks that are currently undertaken by the institutes might feasibly evolve into mature national programs. We believe new science will bring new opportunities to complement conventional approaches. We can hope that national policies will favor increasing investment and well directed research through judgment based more on biology and resource endowments than on caprice or misapprehension.

Finally, we understand that if desired rates of economic development occur, even higher proportions of our products will be use for livestock feed. This has strong implications for the relative demands for maize and wheat.

The Productivity Issue

We are among those who argue that improved technology lowers costs of production. Generally, although not always, these efficiencies increase incomes to those who farm or who hold the agricultural assets. This increased agricultural income generates rounds of spending, which can become an engine for economic development. We are impressed with the need to

quantify the flow on effects of agricultural development. This general economic benefit to people and countries is one of the beliefs that motivate our efforts. Hence, when we talk about our own priorities, we talk about them in terms of the productivity of resources held in agriculture rather than about production of agricultural commodities.

One of the things that I see us doing in the future is expanding our emphasis on networking. This is now in the planning stage. Scientists from several countries are involved, and their efforts are focused on a particular problem. One application that we are currently contemplating could focus on problems such as weeds, fertility, soil structure, tilling and salinity, inherent in sustaining yield increases in the ever more intensively used lands under the rice-wheat rotations from Pakistan to Bangladesh. In this application, the focus is beyond agronomy and technology generation; it will look to science as the underlying relationships on which sustainable yields must be based. Such networks might plan joint research, partition problems according to competencies, share data and analysis, and ensure the professional and technical quality of the research itself.

This issue of sustaining yields is one that is getting our increased attention. Derek Byerlee reports that on the basis of some of his research in Pakistan yields are staying constant, while inputs are increasing and management skills among farmers are improving. So we have in effect lowered productivity of resources that are committed to rice-wheat rotation. We are considering organizing a network of scientists, soil chemists, soil physicists, and microbiologists to focus on that set of problems.

New Science

We are all aware of the startling developments in science as molecular biologists, biochemists, and others have brought their discoveries to bear on issues in plant improvement. CIMMYT has moved in deliberate ways to take advantage of these developments and has established consulting and professional relationships with leaders in these and related fields.

We have done so because, as others, we are impressed with the advantages latent in the new techniques and feel it is only prudent to take steps to assure access to unfolding developments. One such step is to add a molecular biologist to our staff and to bring into play the physical and organizational infrastructure necessary to support these activities.

Our thinking about the extent to which CIMMYT should invest in new science is shaped by three considerations: First, we see ourselves applying the techniques others develop--we are more tool users than toolmakers; second, we must ensure that CIMMYT is able to employ new findings in the practice of plant breeding as they become applicable; third, we recognize that beyond CIMMYT's own requirements, national programs look to us to help them stay abreast of new developments.

Our current collaborative work using the new tools of plant breeding focuses on tissue culture concentrating on finding new ways to maintain and multiply the hybrids emerging from wide cross programs; on callus work to induce chromosomal breakages; and electrophoresis to identify the extent of gene transfer occurring through intergenetic and interspecific crosses. The work currently underway is aimed at bringing traits out of wild relatives into maize and wheat. Our special concerns are selected disease and stress conditions.

Another major new technology that appears to be applicable to CIMMYT's work is the use of gene probes. These could be used to screen large amounts of materials in the laboratory, reducing the need for large field experiments. They could also be used for diagnosis, such as ascertaining the presence of a virus and to assess the success of efforts to transfer alien genetic material. And perhaps, just perhaps, we could become the repository for such probes or clones as they are developed, both by ourselves and by others around the world.

While much has been promised by those who pursue the applications of new science to plant breeding, there are grounds for caution. For example, while genes can now be transferred and spliced, those in maize and wheat have not yet been mapped for function. Moreover, regeneration is still more an artform than a science. Until these challenges are met, the techniques related to splicing have limited applications for CIMMYT.

There is much to suggest that we make haste slowly. Even so, I am impressed by the commitment that major private plant breeding companies are making in this field with some reporting as much as 10-15 percent of their research resources devoted to biotechnology. We are mindful of Thomas Huxley's observation that "a customary fate of new truth is to begin as heresy and end as superstition."

Biotechnology is a fast-breaking field. We must organize so as to ensure that we know what developments are relevant to our needs and can move quickly to incorporate them. This will not only require expertise in the field of biotechnology and a recognition of the practicalities of conventional plant breeding but will require sufficient sympathy and familiarity that an augmented supply of science finds a responsive demand. The steps that we are taking are designed to serve those ends. We see a continuing central role for conventional breeding, and, to the extent desirable, we want to augment its efficiency through relevant new tools.

Germplasm

As in the past, germplasm will remain CIMMYT's major product. Our work in germplasm development has tended to favor the better environments of developing countries. This is true for wheat, where much of the attention of the past has been on well-watered areas. That emphasis was quite appropriate given that some two-thirds of the developing world's Spring wheat is grown in such environments. Most tropical maize, on the other hand, is grown in the presence of significant environmental threats, with the well-watered areas suffering the menace of disease and insects while the drier areas encounter the dramatic effects of drought. Overall progress in bread wheats, Durum wheat, maize, and triticales has ranged from remarkable to extraordinary. And what about the future?

In deciding the emphasis of the future, we must recognize the importance of the favored environments and at the same time stay consistent with the 1986 TAC priorities paper, which cater more to the needs of the more difficult environments. In deciding on the relative importance of each, we must integrate the differing effects on economic development of new technologies, enhanced productivity, and increased income inflows, along with the probability of achieving results.

As we view research on wheat for well-watered areas, emphasis will be placed on maintaining the gains achieved. Greater attention, however, will be given to materials for more difficult environments. Even if the probable gains were less in the poorer environments, a concern for the poorest coupled with the perception that they tend to occupy the most difficult environments would still be cause to focus on these areas. We cannot say much about the final effects until added rounds of spending of given productivity changes in the two environments. The relative size of such parameters must rate a high priority for economists.

Major efforts are now underway on materials that can accommodate drought stress. The maize program was initiated several years ago, then set aside, and it is now being revived. This research tends to show that maize selected under both drought-stress and well-watered conditions tends to perform much better under drought-stress and somewhat better in well-watered circumstances than does maize selected only under well-watered conditions. Work on Spring bread wheat, on Durum wheat, and on triticale is also well along, and we expect good results given the resources being committed.

Work is underway on wheat for more tropical environments and surprising progress has been made. One aspect of that work involves resistance to disease that, while common to such environments, are less commonly encountered in traditional wheat-producing areas. For selected areas already producing wheats, work is underway that will result in more late heat tolerance for wheats.

For both maize and wheat, there is an expanded effort on earliness. This characteristic offers two advantages. The first is to permit escape from diseases of heat or drought. The second and the one becoming more widely recognized is that earliness enables more intensive cropping, implying more options for farmers.

In reaching for these goals (earliness, tolerance for heat and drought, accommodation to problem soils, and new classes of disease resistance), CIMMYT breeders frequently work directly with concerned national programs. Those relationships will be enlarged and fortified as this class of work expands.

In assessing these lines of work from the perspective of potential benefits at the farm level, we are convinced that we need to know more about these important issues for priority setting and policymaking and are investing in acquiring the needed understanding. Combining these insights with those from a more global perspective should help us and our national programs colleagues to have a clearer sense of priorities.

We have greatly augmented our capacities to serve as curators of selected portions of the world's germplasm of maize, Durum and Spring bread wheats, and triticales. Fulfilling our responsibilities in this area will involve collaboration with several national programs, especially in Latin America for maize germplasm. A substantial portion of the desired materials is in storage, and we are developing the associated data. It is satisfying to report that machinery will soon be in place to satisfy a well-defined portion of the world community's needs.

Professional Training

CIMMYT and its predecessor agencies have invested heavily in supporting the efforts of National Agricultural Research Systems (NARS), with a primary part of this effort expended in augmenting human capital through various kinds of training and consulting. The wheat program staff suggests that as much as 45 percent of their total effort can be ascribed to these activities. We will continue that emphasis in the future but will redirect some of the energies.

We must find ways to multiply the energies we are investing in training on agronomy and crop technology generation. The demand for these skills in developing countries is enormous compared with the training capacities of the International Agricultural Research Centers (IARC's). We have moved in this direction through an expansion in our in-country training efforts. In time, we hope to see more of this training being done by national programs or being offered on a regional basis under the auspices of the more mature national programs. If this occurs, CIMMYT would supply course structures, training materials, counseling on conducting the training, and, at times, staff to participate in such programs.

As in the past, efforts in training will rely heavily on learning by doing. Given new developments in instructional materials and a clearer understanding of their potential role, we are moving to develop more such material. In this case, we are learning by doing as we discover the applications of supporting materials to reinforce the lessons of the crossing-block, the breeder's plots, and the fixing of priorities for production trials.

We have long had a program for visiting scientists from NARS in which they work alongside our staff in pursuit of particular research themes or to familiarize themselves with specific

methods of materials. This too will continue. We are also adding the opportunity for participants to refurbish research skills. Our plans are that participants will remain here for 4-6 months; most of them with data from projects undertaken at home. We will provide them with the opportunity to analyze, to pursue related research through the library, and to write research reports. This will meet a need forcefully expressed by many of our colleagues: that results are not available to peers because researchers do not have the time to analyze and write and that certain research skills atrophy because of that same constraint. Interest in this program is widespread, and we have had extraordinary financial support from donors and from the private sector. Our new training facility will play a crucial role in this undertaking.

Finally, we see a growing need for new specialized courses focusing on a single theme or on closely related themes such as that offered in pathology and funded by the Dutch. These themes would be designed and developed in Mexico, based on the experience of network colleagues and our own staff, and made portable so that they could be offered on a regional or national basis.

Our work in training has done much for human capital formation in agricultural research. What is too little appreciated is what this can do for CIMMYT. First, we have the opportunity to learn from the accumulated field experiences of participants in the programs. Beyond that, and largely unrecognized by the training staff with their own periodic involvements in research and continuing close connection to the research of others, are a vehicle through which CIMMYT's experience is synthesized, impressions formed, and procedures are formulated and improved. These procedures are basic to the development of training programs. It is in training then that CIMMYT's wide experience can be gathered, integrated, and then framed in concrete terms.

Work for Africa

Projects on Africa sharply increased through collaboration with U.S. Agency for International Development (USAID) and Canadian Institute for Development Assistance (CIDA). An increasing proportion of our energies over the next decade will be focusing on activities related to Sub-Sahara Africa. Our commitments there will surely be larger than that implied by the areas of maize and wheat--18 percent and 6 percent of developing country maize and wheat--or by the proportion of the populations dependent on the two crops. Commitments will be small, however, when measured in terms of the need for support and of the potential impact.

This work will be representative of the full range of products that CIMMYT delivers to national programs. A considerable portion of the effort will be in germplasm development. Given the urgency of the food and income problem, we have moved our work on intermediate altitude maize to Africa, are now planning to strengthen our forces by working on germplasm for the humid and subhumid tropics, and are contemplating a shift to bolster efforts related to maize's capacity to accommodate drought. In doing this, we expect substantial cooperation with the International Institute for Tropical Africa (IITA), France's agricultural research centers (CIRAD, SPAAR), and other teams being assigned to the region by donors to the CGIAR.

We have every faith that African farmers will use new technologies. Recent evidence from Ghana where CIMMYT staff has worked with the national program through a bilateral project funded by CIDA supports that faith. In a survey of maize farmers, high rates of adoption of improved varieties introduced from the international maize network of nitrogen fertilizer and of new seeding patterns were evident in selected areas. There will be more evaluation of the Ghana experience in the near future and of other such activities.

Training efforts in Africa will also be fortified. It is our hope that a significant portion of the training required, most notably that related to production agronomy, will be undertaken within African programs.

In our view, there is considerable scope for working with national programs in planning and assessing the directions of their work on maize and wheat. This type of counseling could contribute much to the efficiency with which notably scarce national resources are used. In reflecting on priority setting within national research programs, there are many cases in which it is relevant to ask if too many or too few resources are devoted to maize or wheat research. Such decisions, of course, are properly in the hands of national program leadership; even so, we can provide pertinent information. Furthermore, in collaboration with such newly emerging entities as SPAAR, CIMMYT staff will be a good source for information about high-priority investments for potential donors in the activities of national programs.

Finally, we see ourselves as more actively engaged in direct collaboration with other IARC's whose mandates include work for Africa. One potential form of such collaboration is in research on technology generation involving several IARC's and relevant national programs. While we believe that others could do this job, there are two good reasons for us to actively participate. The first is the overwhelming urgency of the need for improved technologies appropriate to the circumstances of African farmers. The second is that African support for research in Africa would be substantially fortified by examples of successfully applied or adaptive research.

Sustaining Momentum

By any standard of measurement, the CGIAR system must be regarded as a marvelously successful venture. The recently concluded CGIAR impact study gives ample evidence of this. One welcome result of the study is that it should quiet apprehensions about the distribution of the benefits from IARC research. The evidence shows widespread benefits, especially to poor consumers. This should be a comfort to those who were concerned about benefit flows. This is not, of course, to suggest that all is well on the income distribution front, but rather that the earlier, more strident critics seem to have been well off the mark.

How can CIMMYT and the CGIAR best maintain the momentums that have contributed so substantially to agriculture in developing countries? The earlier discussion makes the case that the spirit of innovation must hold sway, not just in research itself, but also in contributing to new forms and structures in collaboration, in product, in training, and in procedures.

Sustaining momentum relates not only to support for the IARC's but also to bolstering support for the agricultural research programs of developing countries. During CIMMYT's short 20 years, we have seen that support oscillate first for one institution and then another. We know that constancy strongly influences the utility of research and that on-again, off-again support seldom leads to acceptable payoffs. We also know that sustained support will probably only come after national decisionmakers are convinced that they cannot do without agricultural research and that their constituents will challenge their judgment if support is inadequate. And we know that those convictions can only come if research programs give clear evidence that an investment in their research is an investment with high payoffs.

CIMMYT must also maintain its energies and does so in the face of more subtlety in our understanding of the potential payoff to research. The convictions of an earlier day were maintained by rallying cries that gripped the imagination--"Food for hungry bellies." Today's shibboleths sound faint and pedantic by comparison. We must also, even with the increasing emphasis on new science, maintain the luster of more conventional forms of research, forms that will surely provide the gains of the next decade and more. Finally, in the face of

apparent abundance, we must gather the energies to add choice to the lives of the desperately poor.

Surely these are formidable challenges, but these do not suggest that this is the end. To paraphrase Winston Churchill, "it is not even the beginning of the end, but it may well be the end of the beginning." The circumstances of the next two decades will differ markedly from those of the last two. With the experience, the energy, the wit, and the innovative spirit of our staff, we will reach new highs, with an expanding array of viable options to national agricultural research programs and, through them, to farmers.

THE GREEN REVOLUTION: THE ROLE OF CIMMYT AND WHAT LIES AHEAD

Norman Borlaug[1]

I wish to reflect upon some of the organizational hallmarks that have helped Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) play such an effective and catalytic role in agricultural development over the past 20 years. In doing this, some of the agricultural research methodologies and new institutional systems that CIMMYT has played an instrumental role in developing are of special significance. I also wish to reflect on what are likely to be significant developments in agricultural development in the years ahead and CIMMYT's role in this.

The Forerunner of CIMMYT, The Cooperative Mexican Agricultural Program

In tracing the evolution of CIMMYT and its contributions to improving the productivity of maize and wheat, one must begin with the Cooperative Mexican Agricultural Program (CMAP), which was launched in 1943 as a joint undertaking between the Mexican Ministry of Agriculture and the Rockefeller Foundation. Those of us who were members of the research staff of the Mexican Government-Rockefeller Foundation Cooperative Agricultural Program (Oficina de Estudios Especiales) during 1943-60 are deeply obligated and grateful for support from many officials and employees of the Government of Mexico and from the Rockefeller Foundation, which paved the way for the establishment of CIMMYT. Among this group who merit special acknowledgment of outstanding support and guidance were: Ing. Marte R. Gomez, Ing. Gonzalez Gallardo, President Adolfo Lopez Mateos, Ing. Julian Rodriguez Adame of Mexico, and the "four horse-men" of the Rockefeller Foundation: Drs. E.C. Stakman, Paul Mangelsdorf, Richard Bradfield, and J.G. Harrar. Contrary to the general public's perception, the research objective of this pioneering program was much broader than the development of improved high-yielding disease resistant crop varieties. Over its 20-year lifespan in Mexico, this program developed improved maize and wheat production technologies appropriate to the conditions of farmers in Mexico as well as in many other developing countries. Priority was given to pragmatic, interdisciplinary research aimed at overcoming pressing production problems constraining productivity. The products of this research were also shared freely with the global scientific community.

One of the most significant contributions made through this cooperative effort was to help build a national agricultural research system in Mexico. Training of local researchers, therefore, was a major activity from the start and perhaps one of the program's most significant contributions. Over 700 Mexican research workers received in-service training, and 200 individuals received Rockefeller Foundation fellowships to pursue M.S. and Ph.D degrees.

During its two decades of operation, the Mexican Government-Rockefeller Foundation cooperative agricultural program achieved significant productivity impacts, helping the country to reach self-sufficiency in maize and wheat production in the fifties. The impact of this research on increased production was achieved rapidly by pursuing a policy of transferring the new production technology from research plots to farmers' production fields as soon as significant improvements became available. In the early years, before there was an extension service, the transfer was done by the research scientist. This had a double advantage: (1) it achieved early impact on increasing production; and (2) it made the research scientists directly aware of the strengths, weaknesses, and risks of the new technology; and (3) it permitted the research scientist to rapidly shift research priorities to meet new production problems.

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[1]The author is a consultant with CIMMYT. A version of this paper was first presented at the Ceremony Celebrating the 20th Anniversary of CIMMYT.

Production Impacts In Mexico

Since the sixties, Mexico has continued to make research impacts in maize and wheat through its own research efforts, as well as through its research partnership with CIMMYT. Between 1961-65 and 1982-84, Mexican wheat production increased at an average rate of 5.1 percent per annum and maize production at a 3.0 percent annual rate. Today, Mexico ranks 5th in maize production and 15th in wheat production in the world. National yields of maize have increased at a rate of 3.1 percent per annum since 1970-72, with the total area devoted to maize cultivation declining slightly. Growing deficits in domestic maize production have been caused primarily by the very strong demand for this cereal grain as a poultry and livestock feed. The current average national yield for Mexican wheat is approximately 4 tons per hectare, the highest in the developing world and only surpassed in the developed world by a few European countries. This is due largely to productivity gains. Mexico once again is self-sufficient in wheat production.

But to remain self-sufficient in wheat over the next 20 years, with the growing demand resulting from population growth and increased per capita consumption, is the real challenge. The possibility exists to extend the cultivated area southward during the winter season into more semitropical areas on the Pacific coast and into the northern humid gulf coast of Mexico. To achieve this objective will require the development of varieties with a high level of resistance not only to leaf rust but also to Helminthosporium, Gibberella , Septoria, and to a complex of root-rot producing organism, especially Sclerotium rolfsii. Mexico's need for research to exploit this potential coincides with CIMMYT's international research effort in "tropical wheat" initiated in 1981.

A second avenue for increasing Mexican wheat production is through augmenting the underexploited area and productivity of wheat sown during the summer rainy season at high elevations, especially on the central plateau. Research efforts during the late forties clearly established the biologic and economic feasibilities of production under these conditions. Since the harvest from the traditional winter production areas was adequate to meet demands until the late seventies, this production potential remained unexploited. Within the past 5 years, the area sown to summer wheat has increased rather dramatically. Expanded cooperative research by CIMMYT-INIA to broaden the spectrum of resistance to a number of foliar diseases, as well as for tolerance to high levels of soluble aluminum, is essential if the full potential of summer wheat production at high elevations is to be exploited. CIMMYT also has interest in development of such research for use in the Andean region.

Establishment of CIMMYT

The success of the cooperative program in Mexico led to the creation of INIA, now (INIFAP), as well as CIMMYT. Upon the request and insistence of the late President of Mexico, Adolfo Lopez Mateos, in 1964. INIA assumed the national mandate to produce research results for Mexican farmers. CIMMYT assumed an international mandate to support and complement the maize and wheat research work on national programs throughout the world, but with emphasis on the production problems of developing countries.

A Shared Legacy

In commenting on CIMMYT's contributions to raising maize and wheat productivity, I will treat the achievement made during the years of the center's predecessor organization as part of CIMMYT's overall legacy. Given the considerable overlap in research personnel from both organizational phases, and the fact that CIMMYT's operational philosophy, in large part, is modeled after its predecessor organization, it is appropriate to view both phases as part of the same continuum. It should be noted, however, that many research breakthroughs, at least in wheat, were achieved prior to the establishment of CIMMYT.

CIMMYT's Research Contributions

Its staff--past and present--has played pioneering roles in the development of commodity-focused agricultural research in the Third World. Most significant among its achievements has been the development of high-yielding wheat and maize varieties with broad adaption and enhanced yield dependability and the development of the agronomic practices that permit these improved materials to express their high genetic yield potential. The greatest commercial benefits of this research have been achieved in wheat. But considerable impacts in maize are also on the verge of becoming reality. I also consider the progress to develop triticale as a commercial crop and the efforts to develop nutritionally superior maize materials to be important research achievements. More recent efforts to develop germplasm with greater dependability of yield under environmental stress situations and CIMMYT's work in developing crop management research procedures are also significant activities.

Broad Adaptation

Until the fifties and still present to some extent, plant breeding dogma held that the only way to ensure the development of high-yielding, well-adapted varieties was to select them through all segregating generations in the location where they are to be grown commercially. Faced with the urgent need to develop wheat varieties with acceptable stem rust resistance in Mexico, a decision was made to ignore dogma and use several ecological zones that would permit the growing and selecting of two segregating generations of progeny each year. Since different races of stem rust were present in various locations, this permitted a more effective screening program to build up a more durable resistance (broad spectrum) to stem rust as well as to other pathogens. With two breeding cycles every 12 months, a new variety could theoretically be produced in 4 years, rather than 8 years required with the conventional methods.

We used two locations in Mexico to accomplish this. The locations were separated from each other by 10 degrees of latitude (and with changing day lengths) and with differing temperatures because of a change in elevation of 2,600 meters. Segregating populations were shuttled, grown, and selected in these two very diverse environments. Some unexpected results soon became evident from this unorthodox breeding approach. Progenies from certain individual plant selections from a very few crosses were soon observed in F3 and F4 plants to be early maturing and equally well adapted at a number of locations in the high-central plateau around Mexico City, in the Bajio region at Irapuato and Leon, and in the Sonoran coastal plain at Ciudad Obregon. Once this unique breadth of adaptation--combined with early maturity--was recognized, the intensity of selection pressure was increased. Our aim was to try to identify individual plants that combined not only resistance to stem and leaf rust--which was the original objective--but also had broad adaptation and resistance to shattering and lodging.

By 1948, the Princess of Serendip had smiled on our unorthodox shuttle breeding effort. Two new varieties, Yaqui 48 and Kentana 48, had proven themselves to be high-yielding, early-maturing, resistant to shattering, and highly resistant to stem rust and moderately resistant to leaf and stripe rust. Because of this combination of traits, these new varieties could be grown successfully with proper dates of planting over a range of climatic and soil conditions in Mexico. These varities with their day-length insensitivity and broad-based rust resistance were also later shown to be top yielders in many other production areas in developing countries. This made the tasks of seed production and distribution easier in the early years. With only a few varieties needed to serve commercial farmers--rather than a dozen or more that would have been necessary if narrowly adapted varieties would have been developed, the work of newly formed national seed agencies was made much more manageable.

While I am a proponent of the utility of developing broadly adapted materials, I am not advocating that plant breeders should try to develop a single universal variety. This would be

unwise from a genetic erosion and disease susceptibility standpoint as well as in terms of trying to optimize yield potential, especially in many problem soils. Neither should the emphasis be on the development of materials with such narrow adaptation that they are only suited to very small microenvironments. In this sense, a crucial research issue is the delineation of boundaries for the various broadly generalized production environments.

While we were empirically manipulating photoperiodism through our shuttle breeding techniques. Drs. Hendricks, Borthwick, and Parker of the U.S. Department of Agriculture (USDA) were providing the theoretical explanation of this phenomenon. Through their work on the role of light in plant photoperiodism, seed germination, stem elongation, flowering, and fruiting, they were able to explain underlying principles of varietal adaptation. In the early years of study, they believed that sensitivity of daylight was controlled by one or two major genes. Current evidence indicates that, although there are probably only two major genes involved, there are also a large number of modifier genes. The maturity system is further complicated by the interaction of genes that control photoperiodism and those that control vernalization (temperatures), making it possible to isolate many different genotypic combinations.

Breakthrough in Genetic Yield Potential

Though successful in combining disease resistance and broad adaptation in the improved tall cultivars, we continued to face the barrier that lodging was imposing on grain yield. As the use of nitrogenous fertilizers increased, lodging had become the major problem limiting yields, especially in Sonora Mexico. During 1952-53, we made a concerted, but unsuccessful, effort to find suitable sources of shorter and stronger straw varieties for use as parents in the breeding program. The entire world wheat collection of the USDA was screened for straw height and strength. I learned in late 1952 of Dr. Orville Vogel's preliminary successes of incorporating the dwarfing genes from Norin 10 into winter wheats from the late Dr. Burt Bayles, then senior wheat breeder for the USDA. I wrote Dr. Vogel and requested genetic materials containing Norin 10 dwarfing genes for use as parents in the Mexico spring wheat breeding program. In 1953, Dr. Vogel kindly sent me a few seeds from three different F2 selections from the cross Norin 10 x Baart and a few seeds from each of five superior F2 plants from the cross Norin 10 x Brevor.

Our first attempt to cross the Mexican materials to Vogel's materials was unsuccessful because the resulting F3 plant was used as the female parent, which was highly susceptible to all three rusts. The F3 plant was killed outright without producing viable F1 seed. Using the few remaining seeds, a second attempt was made in 1955 and was successful. In the F1 and F2 progeny derived from the superior Norin 10 x Brevor cross, it became evident that a new type of wheat--much higher yielding than we had seen before--was forthcoming. In the early generations, progeny derived from the Norin 10 x Brevor x Mexican variety crosses had many deleterious genes. The more obvious and worrysome was the high degree of male sterility, especially in the later tillers, which led to much promiscuous outcrossing. The amount of outcrossing in the first two cycles of breeding was so high that it casts doubt on the reliability of many of the pedigrees. The second serious defect was grain quality. The grain invariably was badly shrivelled, soft in texture, and had weak gluten. A third serious defect was the high degree of susceptibility to stem and leaf rust introduced in the progeny from the Norin 10 x Brevor parents.

Strong selection pressure was exerted to attempt to overcome these problems, and various types of crosses were made. By 1962, two high-yielding semidwarf Norin 10 derivatives (Pitic 62 and Penjamo 62) with broad-based rust resistance and adaptation to a range of production environments were named and released in Mexico for commercial production. While our research objective in using the semidwarf materials was to reduce the incidence of lodging, we obtained an unexpected benefit of markedly higher yield potential, due to the partitioning of more of the total dry matter into grain production. The newly released semidwarf varieties

had yields of 6-7 tons per hectare, compared with the 4-4.5 tons per hectare of the tall, improved Mexican genotypes that were used as parents. Obviously, additional genes were introduced into the formerly so-called "high-yielding" Mexican varieties by their Norin 10 and Brevor parents, with both parents contributing to increased yield potential.

Diffusion of Semidwarf Wheat Varieties

Since the early sixties, more than 400 high-yielding semidwarf wheat varieties derived, at least in part, from crosses made at CIMMYT have been released in some 50 countries. These materials have much better disease resistance than the local varieties that they have replaced. They also produce more grain than local materials under low fertility conditions and have the capacity to yield twice as much as traditional varieties under more optimum fertilizer and moisture conditions.

The area in which these semidwarf varieties have demonstrated superior yield performance is vast: 50 million hectares, half of the total wheat area in the developing world. Immense as it is, this wheat-producing area shares many common bonds in terms of varietal requirements. Rusts are the major disease problem, moisture is generally not a limiting factor, and intermediate-to-early maturity is the major growth-period requirements. The materials developed in Mexico had these characteristics. In addition, their day-length insensitivity and other agronomic characters made them adapted to a very broad range of production conditions. The current coverage probably delineates the boundaries of these major production environments. The fact that 50 million hectares have yet to be planted to improved varieties indicates that these production areas require different varieties than those produced to date. New gene pools and more specific selection criteria are likely to be needed for untouched problem soil areas. These areas primarily include acid soils with high levels of soluble aluminum, alkaline soils with high levels of sodium, and soils in marginal rainfall areas.

Development of High-Yielding Maize Materials

Local maize varieties in the tropics and subtropics suffered from a similar problem to traditional wheat types. They were leafy, grew too tall, and tended to lodge heavily when grown under improved agronomic conditions. Compared to U.S. Corn Belt materials, tropical maize materials had very poor harvest indices, with up to two-thirds of their total dry matter partitioned to stover instead of grain. CIMMYT has made significant contributions in improving the harvest indexes of tropical and subtropical maize materials. The center's efforts to develop high-yielding open-pollinated maize varieties have also been a unique research contribution. These efforts led to the development of more grain-efficient, yield-dependable varieties whose seed could be saved by the farmer for planting the next season without significant loss of vigor.

A recurrent selection scheme, rather than the introduction of a dwarfing gene, has been the basis for repartitioning total dry matter weight toward greater grain production in maize. The results have been the same: the improved maizes have much higher genetic yield potential than do the traditional local varieties. A system of multilocational testing, first in Mexico and later in dozens of locations in other countries, has broadened the adaptation of these maize materials, not only from the standpoint of photoperiod insensitivity but also in terms of resistance to important foliar diseases and to certain classes of insects. As a result of this work, new sources of genetic variability have been introduced into national maize improvement programs; germplasm, which can be readily used, is being used to improve locally developed materials. The maize germplasm developed through this improvement methodology has been a collaborative effort with national scientists throughout the developing world. The partnership has produced 1,000 experimental varieties, and some 150 varieties have been released by 30 national governments for commercial cultivation.

Quality Protein Maize

The discovery of the improved nutritive value of opaque-2 maize at Purdue University in 1963 ushered in a period of great euphoric activity directed toward developing maize varieties and hybrids with high levels of lysine and tryptophane. The euphoria faded to frustration. This effort was discontinued by virtually all of the private sector maize seed companies, as well as government and university programs, as the discovery of unfavorable linkages associated with the opaque-2 gene became apparent.

The CIMMYT maize breeding program, with excellent close collaboration with the geneticist-breeders and biochemists, has gradually overcome the adverse linkages. Several open-pollinated quality protein maize (QPM) varieties with high grain yield, hard textured kernels (flint or dent), and good disease and insect resistance have been developed by CIMMYT. This work has shown that the adverse linkages between high levels of lysine-high tryptophane (opaque-2 gene) and low grain yield, soft grain texture, susceptibility to ear rots and insect damage can be, and have been, overcome. CIMMYT is now developing QPM hybrid maize varieties. OPM varieties are currently being grown commercially in Guatemala and China.

It appears that the development, acceptance, and use of QPM varieties are now at a position similar to that of the semidwarf wheat varieties 20 years ago in India, Pakistan, and the United States. Many noisy skeptics said that the wheat varieties would never be accepted. Nevertheless, look what has happened in the past 15 years! I predict QPM too will have "its day" in the years ahead.

The New Crop: Triticale

Triticale is an amphiploid "species" developed from crossing wheat and rye, employing either durum or bread varieties as the wheat parent. This new cereal crop, which promises to become an important food and feed grain crop in many areas of the world within the next decade, is currently grown in at least 10 different countries on a total of about 750,000 hectares.

CIMMYT inherited a small triticale research program from its predecessor organization. At that time, all triticales were tall, of late maturity, and highly sterile; the grain that was produced was badly shrivelled. CIMMYT established a large, broad-based breeding program to overcome these defects. Despite criticism of the program and prediction by some theoretical scientists that these defects--especially sterility and shrivelling of the grain--would never be overcome, one by one they have been, and triticale is now becoming a commercial crop in some countries. Triticale is far superior in grain yield to wheat in acid soils, especially in areas with high levels of soluble aluminum. In many areas with good soils (such as Sonora, Mexico), it yields are as much as or slightly more than the best bread wheat varieties. Triticale is currently being grown on commercial average in the Soviet Union, Poland, Australia, Spain, France, West Germany, Canada, the United States, Argentina, and Mexico, and it is used primarily as a feed grain. Triticale flour (unlike flour from durum wheat), when properly blended with flour from bread wheat and with the dough appropriately handled during fermentation, will produce good bread. In recent years, in certain seasons when environmental conditions are favorable for heavy infection with Karnal bunt, the level of grain infection on wheat bread varieties is heavy enough to adversely affect both the odor and taste of flour and bread. Under these same conditions, grain from durum wheat varieties and triticale varieties are either entirely free of Karnal bunt or only have a trace of bunt.

Crop Production Research

CIMMYT has had a tradition of being farmer-focused in its research approach. While the center is famous for its contributions in plant breeding, improved germplasm has been the only

calling card for the center. While high yielding varieties have served as the catalyst for introducing higher-yielding agricultural technology, the contributions of fertilizer, irrigation, and improved agronomy were essential to the impacts that have been achieved on Third World food production. CIMMYT has played a significant role in advocating the development of a more suitable infrastructure for high-yield agriculture. As evidence in those countries (such as Turkey), where wheat production is most limited by agronomic and economic problems, the center has emphasized crop management research above crop improvement research. This comprehensive approach to agricultural research is fundamental to achieving progress.

CIMMYT has played a leading role in the development of more effective crop management research procedures in which economists and biological scientists work together. The procedures that have been developed place a major emphasis on onfarm experimentation because the production conditions of most research stations are not typical of the conditions faced by representative farmers. These methodologies have been adopted by many national research programs in the Third World and have greatly increased research effectiveness in the development of farm-level production recommendations.

CIMMYT's Institution Contributions

CIMMYT's institutional innovations (the development of international germplasm testing programs, the in-service training programs, and the efforts to build global and regional networks to facilitate information exchange), have been highly effective and have contributed greatly to putting maize and wheat research on a sounder basis worldwide. A brief review of each of these developments is in order.

International Testing

In 1950, the first of four successive stem-rust epidemics struck U.S. and Canadian wheat crops. The greatest destruction happened in 1954 when 75 percent of the durum and a considerable part of the bread wheat crop was destroyed. The primary cause was the virulent race 15B, which was capable of destroying all of the durum and bread wheat varieties used commercially. A race similar to 15B was also spreading simultaneously in Latin America. The standard response to such an epidemic is the rapid testing of wheat lines to identify resistance to the new race of pathogen, then to multiply the seed of the resistant lines as soon as available, while also continuing crossing resistant lines to pyramid and broaden the genes for resistance. A race as virulent as 15B demanded the widest possible testing in the shortest possible time.

A disease of this magnitude forced scientists to search for new solutions, and out of this crisis came initiatives, largely under the leadership of the late Drs. H. A. Rodenheiser and E. C. Stakman, that are still benefiting global agriculture. In 1950, the USDA appealed to seven countries--Mexico, Colombia, Ecuador, Peru, Chile, Argentina, and Canada--to join the United States in testing 1,000 lines of wheat selected from the U.S. world wheat collection and some advance generation lines from several breeding programs as possible sources of resistance to the race 15B. CIMMYT's predecessor organization in Mexico was an active participant and contributed many lines from its breeding program. These 1,000 wheat lines were exposed to the stem-rust populations present in the participating countries. The results of this 1st International Stem Rust Nursery exceeded expectations, and today much of the stem-rust resistance in commercial wheats can be traced to the breeding materials identified from those early nurseries.

There were other indirect benefits of even greater importance in this international cooperative effort than the identification of germplasm with resistance to race 15B of stem rust. A new mechanism for widespread international testing of germplasm--first in wheat and later in many other food crops--was being formed. Before the 1st International Stem Rust Nursey, many

breeders were reluctant to release advanced lines from their breeding programs to fellow scientists for fear the new varieties would be named and released without proper recognition to the breeder or organization responsible. Rarely were early generation, segregating materials distributed to other scientists.

The first attempt to establish a Cooperative International Wheat Yield Nursery was made in 1959 when the Mexican-RF program volunteered to organize, prepare, and distribute the Inter-American Spring Wheat Yield Nursery. This nursery included the most important commercial spring wheat varieties then being grown in both continents, as well as a number of promising breeding lines from programs in Mexico, Canada, the United States, Colombia, Chile, Argentina, and Brazil. The nursery was grown in Canada, the United States, Mexico, Guatemala, Colombia, Ecuador, Peru, Bolivia, Paraguay, Chile, Argentina, Brazil, and Uruguay. This nursery clearly established the broad adaptation of the Mexican varieties in contrast to the limited adaptation across latitudes of the long day-length varieties of Canada, the United States, and Argentina. Mexico was part of the training exercises for the FAO-RF sponsored North African/Near East/Middle East wheat in-service training program. The nursery included the important commercial varieties of the North African, Near Eastern, and Middle Eastern countries and Mexico, as well as the two long day-length varieties, Thatcher (Minnesota) and Selkirk (Canada), and a number of promising new semidwarf lines from Mexico. The Inter-American Spring Wheat Yield Nursery and the Near East Mexican Yield Nursery were combined in 1961 to form the International Spring Wheat Yield Nursery (ISWYN), which is still in existance today and whose data serve--for those wheat scientists who use it intelligently--as an invaluable guide for orienting their breeding programs.

CIMMYT's serves as the hub of the largest germplasm distribution and testing networks in the world today. CIMMYT sends over 1 million packets of experimental seed--carrying significant amounts of useful new genetic variability--to plant scientists in more than 120 countries each year. The results of these nursery trials are recorded at each individual test site and then sent to CIMMYT for data processing and analysis. The results of each year's international nursery are then compiled, published, and distributed among networks of maize and wheat scientists. CIMMYT's germplasm banks--some of the largest and best maintained in the world--supply thousands of seed samples upon requests to scientists throughout the world.

International testing ushered in a new willingness to share advanced generation unnamed lines, as well as early generation materials. This, in turn, accelerated the introduction of materials with genetic variability--the basis of progress in plant improvement--into national breeding programs. It became accepted policy that any line tested internationally could be used by collaborating scientists for breeding purposes or for distribution as a commercial variety, providing acknowledgment of the source of material was given. These developments broke down psychological barriers that had tended to keep the efforts of plant breeders separate. Not only did international testing introduce new genetic variability into national breeding efforts, but it also provided individual breeders with an international system to simultaneously evaluate the adaptation and disease stability of their promising new materials in many different environments. I believe it fair to say that the advent of international testing, which led to an unexpected acceleration in plant breeding programs around the world, marked the beginning of the modern era in plant breeding.

Training and Leadership Development

CIMMYT's has always placed a very high priority on its training and leadership development efforts in support of collaborating national institutions. The center currently counts some 4,000 researchers from 120 countries as alumni of its in-service training courses at headquarters and outside Mexico, and its fellowship program for visiting scientists, graduate students, and pre- and post-doctoral fellows. In these training efforts, CIMMYT has sought to complement the theoretical training that agricultural researchers have received in universities

and technical schools. The training emphasis at CIMMYT has been on actual physical performance of research tasks. A tutorial form of instruction has been emphasized in which in-service trainees and visiting scientists work alongside the CIMMYT staff in the field and in the laboratory. This approach has had a positive motivational effect on trainees and research fellows.

CIMMYT's Research Environment

The center has largely been unfettered by restrictive bureaucratic and political constraints, adequately funded, and supported by an excellent infrastructured of experiment stations, laboratories, and information and administrative services. It has also enjoyed excellent ties to and collaboration with the Mexican INIA/CIANO Wheat Research Program and the support of the Sonora farmers' patronato organization, which supports wheat research. This environment has permitted scientists to focus their energies on the research agenda at hand and has resulted in high levels of motivation and commitment among the staff. As such, CIMMYT has helped to establish a fraternity of maize and wheat scientists and a standard of excellence for thousands of researchers from around the world. CIMMYT's achievements have also helped to give the agricultural research profession greater credibility in political circles in the Third World.

Development of Scientific Information Networks

CIMMYT has always given major emphasis in its program activities to the maintenance of close working relationship with national program scientists. This has involved frequent travel by CIMMYT headquarters staff to the research plots of national collaborators, providing training and visiting scientist fellowships for scientists from developing countries to come to Mexico, providing assistance in obtaining funds for graduate studies to pursue master's and doctorate degrees and the provision of published scientific information, generally on a cost-free basis. In an earlier day, much of the staff travel to collaborating countries was done by the staff based in Mexico. In particular, CIMMYT's directing staff traveled widely each year, visiting with research collaborators, administrators, and policymakers in many countries. As the number of countries with which CIMMYT had research relationships grew from 60 to more than 120, new institutional mechanisms were necessary to handle these interorganization relationships more effectively. The development of the regional program concept has been a major component of the current institutional strategy. Half of CIMMYT's scientific staff is now posted in regional programs. Much of their activity is similar to what staff traveling from Mexico attempted to do in previous years. The major advantage to the regional program concept, however, is that CIMMYT has representatives actually living and working in major maize- and wheat-growing environments of the developing world. With more frequent contact and a more intimate understanding of research problems and opportunities, the linkages with national programs have been enhanced.

Contributions to Increased Food Availability and Agricultural Productivity

CIMMYT's research efforts have been ongoing for 20 years and, if the predecessor period is included, for more than 40 years. What has been the impact? The center's contributions to increased agricultural productivity are intertwined with the efforts of many scientists, production specialists, extension workers, policymakers, and farmers. In germplasm development, the staff has worked in a partnership role with national research programs. Varieties emanating from this work are joint products. CIMMYT itself does not seek to name or release varieties; this is the responsibility of national crop research and seed certification programs. Furthermore, farm-level impacts are the consequences of many other components besides improved varieties. Increased use of fertilizers, irrigation, improved agronomy, plant protection, and greater policy incentives all have played major roles in the productivity advances that have been made.

The Green Revolution

CIMMYT was born in the midst of, and was largely a consequence of, a world food production crisis--centered in Asia during the early to midsixties. With countries lacking foreign exchange to purchase food imports, dire predictions were being made that without perpetual food aid, countries in the region faced continuing, and probably worsening, famines. Political leaders, many with their back against the wall, became receptive to the then radical advice of a handful of scientists who argued forcefully for the introduction of the new high-yield wheat and rice technologies developed in Mexico and the Philippines. Over-ruling the counsel of some local researchers, India and Pakistan's national leaders took calculated risks and after 4 years of widespread onfarm testing decided to embark on a major production program to introduce the new seed-fertilizer technologies as quickly as possible. Once farmers saw the yields of the new wheats (and improved agronomic practices) on demonstration plots on their own farms, they became the major spokesmen for increased adoption. The spread of these new wheats and rices is unparalleled in the history of agriculture, except perhaps for the spread of hybrid maize in temperature-zone countries during the forties, fifties, and sixties. In less than 20 years, half of the Third World's wheat and rice area has come to be planted with these modern genotypes.

Many initial reporters chose to depict the new wheat and rice technologies as a wholesale technological transfer of high-yield, temperature-zone farming systems to peasant farmers in the Third World. In reality, however, this was not the case. More accurately, the term "green revolution" should be used to identify the beginning of a new era for agricultural research and development--which continues today--in which modern principles of genetics/plant breeding, agronomy, plant pathology, entomology, and economies have been applied to develop indigenous technologies appropriate to the conditions of Third World farmers.

The really important attribute of the new green revolution technologies was that they were yield-increasing, cost-reducing, land-augmenting technologies. It was the introduction of this new technology, combined with adequate policy incentives that led to significant productivity gains. The combination of the new varieties and higher yielding production technology has allowed all farmers to increase total farm output through higher yield levels and through the possibility for increasing cropping intensity. Coupled with stimulatory economic policies, farmers had incentives to produce surplus production for commercial sale. Not only did these innovations lead to increased income levels for farmers, but they helped to lower production costs per unit of output.

These more productive farming systems led to the development of new rural industries and sources of employment. Consumers were the major beneficiaries, especially the urban and rural poor, whose diets rest heavily on cereals. Because per capita production has increased in rice, wheat, and maize, the rate of increase in food prices has been considerably dampened. This has permitted improved nutrition and helped improve the welfare of millions of low-income people.

Today, the significance of agriculture as the engine for overall economic development in the Third World has been convincingly proven. In the words of economist John Mellor, "the research breakthrough symbolized by the new cereal varieties offered an opportunity to turn away from defeatist agricultural development policies directed toward the race to keep food supplies in balance with population growth and famine relief and to turn toward a positive role for agriculture, which places it at the leading edge of the total development process."

Productivity Improvements in Maize and Wheat

Increased investments in agricultural research and rural development have helped to more than double maize production and to more than triple wheat production over the past 20 years in

the Third World countries. Slightly less than half of the growth in maize production and 65 percent of the growth in wheat production have been due to higher yield levels. Third World production of both crops has increased more rapidly than population over the past two decades. Since 1961-65, per capita production has increased by 30 percent in maize and by 70 percent in wheat. Virtually all of this increased per capita production of maize have been destined for livestock and poultry feed. Direct-food maize (as percentage of total calories) remained constant at 8 percent. Increased per capita production of wheat caused the major increase in the importance of this grain in human diets in developing countries. Wheat accounted for 16 percent of total calories in human diets during 1961-65 and for 26 percent in 1981-84. These growth rates reflect impressive changes in productivity, especially given the dire predictions of increasing food deficits that dominated the agricultural press only a decade earlier.

When these Third World production indicators are disaggregated into regional statistics, it becomes evident that progress in agricultural development has been uneven across regions. The performance of China has obviously been spectacular, with per annum growth rates of 7 percent in wheat and 5.8 percent in maize over this 20-year period. Strong growth rates also have been registered in the developing market economies of Asia. Wheat and maize production has outpaced population in most of Latin America, except in the Andean countries. The growth rates in Mexico, Central American, and the southern cone countries of South America have been strong. Imports in Latin America have been on the rise, a consequence of rising incomes and growing demand for meat and livestock products. Middle East wheat production has barely kept pace with population growth, while per capita maize consumption has declined. In North Africa, the growth in wheat production has been sluggish, although maize yields have increased at a rate of 2.3 percent per annum. West Africa has had very low growth rates in yields and in production of both maize and wheat. Only in southern and parts of eastern Africa have maize and wheat yields and production increased near the rate of population growth.

It is interesting to note that those developing countries with the best growth rates in agricultural production also have the strongest rates of overall economic growth. With often rapidly rising per capita incomes, these developing countries have also purchased more agricultural imports to help satisfy very strong domestic growth rates in demand for livestock and poultry products.

Critics of the Green Revolution

Despite the tremendous production gains achieved in a very short time--which helped to starve off famine situations of gigantic proportions, the green revolution technologies have been the subject of intense controversy since their introduction.

Will Durant, the historian, once commented that "man's capacity for fretting is endless, no matter how many difficulties we surmount, how many ideals we realize, there is a stealthy pleasure in rejecting mankind or the universe as worthy of our approval." This phenomenon is quite representative of the attitude of many green revolution critics. These critics were utopian intellectuals speaking from privileged positions in ivory towers who had never personally been hungry or ever lived and worked with people living in abject poverty. They seemed to convey the impression that science and technology, if properly organized, could correct all of the social ills and inequities that had accumulated from the time of Adam and Eve up to the present, and thus remove this nasty task from the shoulders of political leaders.

In the initial years, two major lines of criticism were leveled against the green revolution. On one side were the population doomsdayers who said that it was already too late in the over-populated developing countries, that the situation in countries such as India and Bangladesh was hopeless, and that the rich nations would only make things worse in the long run by trying to alleviate suffering in the short run. This group likened the Earth to a

lifeboat that could only hold so many passengers without it sinking. Moreover, they viewed international technical assistance efforts in agriculture as only encouraging more population growth, which, as a result, would lead to a disaster of greater proportions later.

I share this concern about the high rates of population growth in many developing countries and the effects that this growth has had on economic development and environmental quality. But the lifeboat argument was and is premature; we have not exceeded the carrying capacity of the Earth. The lifeboat argument is flawed in that it assumed that all of the world's people have passage on the same boat. In reality, there are at least two lifeboats and maybe more. One lifeboat carriers only 20 percent of the world's people--those who reside in the developed nations and, in relative terms, have first class bookings. The other lifeboat, increasingly overloaded and leaky, carries the remaining 80 percent of the world's people--those of the developing world. It seems cruelly insensitive and short-sighted for those with first class passage--and with plenty of space to take on new passengers--to lead the cry for science to turn its back on the plight of the vast majority of humankind. If this approach were pursued for long, it would lead to widespread social rebellion and, in all probability, to the downfall of the present civilization.

Another major line of green revolution criticism argued that the introduction of the new seed-fertilizer technology would only lead to worsening in the distribution of income and wealth, unless redistribution in the means of production occurred first. Critics in this school labeled the high-yielding wheat and rice technologies as being only suited to the rich landowners who could afford the seed, fertilizer, and irrigation needed to obtain maximum yield potential. It was true that the new technologies increased production costs per unit of cultivated area. What seems to be ignored in this equation, however, is the fact that the new technologies increased output proportionally more than the cost of the new inputs. Green revolution technologies have also been accused of accelerating labor displacement in rural areas because they encouraged mechanization. While this is also partially true for some job categories, it is also true that the new technologies increased employment opportunities greatly in many other job sectors; in other words, the net effect on rural employment was very positive.

The spectacular success of the new wheat and rice seed-fertilizer technologies, no doubt, overshadowed many underlying social and economic problems related to income distribution in the Third World. Development efforts to correct serious inequalities in land tenure and to redistribute more equitably national means of production were probably set back. But, it is now well documented that small farmers--with only relatively brief lag times--adopted the new seed-fertilizer technologies about as rapidly as large farmers. Given their ability to take risks, larger farmers were the first to test the new technologies since they could afford to gamble more. While both groups have benefitted equally in proportional terms, obviously those with more resources received greater benefits in an absolute sense. I personally am not interested in distributing poverty more equitably. Instead, my approach is that we must increase production of food and at the same time strive for more equitable distribution. In countries where resource distribution is highly skewed and unequal, their long-term economic growths are not likely to be sustained without political and economic measures to redress such imbalances. It is a problem, however, that science and technology are not well equipped to handle. Plant species are apolitical creatures. They cannot to coaxed to yield 10 times more on a small plot than they are capable of yielding on a larger tract of land, employing the same technology. The redress of social inequalities is a job that must be tackled largely by the politicians of the world, not the agricultural research community.

In more recent years, some members of the environmental movement have also become green revolution critics. The thrust of their criticisms has a distinct antitechnology bias, combined often with an idealized view of peasant farming as a harmony between man and nature. Arguments in this view often imagine conspirational relationships between scientists and agricultural chemical and machinery companies. They accuse us of trying to get Third World

farmers "hooked" on energy-intensive production technologies that are not economically nor environmentally sustainable. Greater use of chemical fertilizers, pesticides, herbicides, pump irrigation systems, and farm machinery is inherently bad for the Third World according to them. As an alternative, the virtues of more "organic" forms of farming are advanced as the best way to preserve the long-term viability of Third World farmlands and farmers.

It is my belief that agricultural chemicals are absolutely necessary to produce the food that is necessary to feed today's population of 5 billion, which is currently increasing at the rate of 82 million per year. Lest I be misunderstood, agricultural chemicals and fertilizers are like medicines, they are absolutely necessary to produce the food and fiber required by our world population, but they should be used with proper caution. There is no way that the world can turnback to the "good old days" of the early thirties when few agricultural chemicals and little chemical fertilizer were used. There are 5 billion people requiring food today, compared with only 2 billion in 1930. Without increased productivity, how would we provide the necessary food for the 3 billion people that have been added to the world population in the last half century?

This group of critics leaves the impression that the world is being poisoned out of existence by the use of agricultural chemicals. This opinion defies the facts. The truth is that many more people are living a more enjoyable, pleasant, and longer life than any previous generation. In 1900, the life expectancy at time of birth in the United States was 46 years for man and 48 years for women. By 1940, life expectancy for the total population at time of birth had increased to 60.8 and 65.2 years for men and women, respectively. By 1982, life expectancy at birth for the total population reached 70.8 years for men and 78.2 for women, and it continues to increase. The truth for these elitist critics seems to be that life has become so enjoyable that they would like to extend it indefinitely, while enjoying the vigor, enthusiasm, and health of youth. This unrealistic utopian philosophy prevails because those promoting it have forgotten the basic fact that all that are born into this world must sooner or later die and give way for the next generation.

Perhaps the single most important factor limiting crop yields in the developing world is soil infertility, due to either natural pre-agricultural infertility, extractive farming practices, or to deficiencies of primary, secondary, and minor elements brought on by more intensive farming practices. The shrinking of the per capita arable land base in food-deficit, densely populated countries has made it impossible to leave land out of food crop cultivation for green manure crop rotations to help organically restore soil fertility. Fortunately, soil fertility can be effective and safely restored through the right kinds and amount of chemical fertilizer, according to the requirements of different crops, soil types, and environments. Without the restoration of soil fertility, few benefits will accrue from the use of improved varieties and other more productive cultivating practices.

There are some organic gardening enthusiasts who insist that the wide use of organic fertilizer could satisfy all of our fertilizer needs. This, however, is nonsense. The amount of composted organic animal manure (1.5 percent nitrogen on a dry weight basis) that would be needed to produce the 65 million metric tons of chemical nitrogen used today would be about 4.4 billion tons--quite a dung heap and quite an aroma--were it available. This volume of organic materials is equal to twice the world's animal production, with all the additional grain and pasture feeding implications that such an increase would imply. Even now, there are many areas of the world where over-grazing is already causing serious erosion problems.

There is another group of critics that insists that foreign technical assistance programs spawning "green revolutions" are destroying the markets for food-exporting nations. This is a gross over-simplication of facts. In the first place, poor nations and poor people are poor customers. For examples, the food-deficit hungry nations of Africa are today largely agrarian subsistence economies in which 80-85 percent of the total population are poor subsistence farmers without purchasing power. The only way they have of increasing their purchasing

power and standard of living is to increase their agricultural production, so that they have some agricultural produce to sell, and with which they can begin to buy other products and, in the process, join the money economics which will, in time, result in increased trade. Recent trade data for U.S. agricultural products confirm this fact. These data indicate that Third World nations with strong growth rates in their domestic agricultural sectors also have strong overall economic growth. It is also these nations that have increased their imports of U.S. products, not the poor, stagnant developing countries.

The growth that has occurred in human population numbers during this century makes it impossible--even if we wanted--for us to turnback the clock and use the less-intensive production practices that were dominant only a century ago, when world population was under 2 billion and large expanses of land were available for increased food production. In a world of 5 billion, in which bringing new agricultural lands into production has become increasingly more difficult and costly, we have no choice but to increase land intensification on existing farmlands. Such intensification can have adverse environmental consequences, but it doesn't have to. Rather that advocating that we go back to earlier production systems, the solutions lie in using our scientific knowledge to develop technologies that can increase productivity as well as ensure sustainability of production.

CIMMYT's Organization Hallmarks

CIMMYT's primary purpose is to help speed the process of developing improved maize and wheat technologies in the Third World. While the center's principal contacts are national program researchers, developing country food producers and consumers are the target to whom our collective work is directed. Even though national programs carry the primary responsibility for developing and extending improved production technologies to their farmers, CIMMYT also must share accountability. The achievement of wheat and maize productivity impacts on farmers' fields; therefore, it must be the ultimate measure of the value of the center's work--as well as that of the CGIAR system. CIMMYT cannot afford--nor can national program collaborators--to rest on past laurels and achievements. We owe the societies that support which depend upon us for a good return on their investment. Our assigned task is in the final sense to alleviate hunger and human misery--which we must never forget.

I believe that the most efficient expeditious way to develop improved technology is through an integrated research approach. No matter how excellent and spectacular is the research that is done in one scientific discipline, its application in isolation will have little or no positive effect on crop production. It is more comfortable to stand and work in the shade of the tree of your own discipline, even though the forest is made up of the shadows of trees of many disciplines. What is needed instead are venturesome scientists who are comfortable and willing to integrate across the shadows or scientific disciplines cast by all the trees in the forest, and, thereby, produce a technology capable of increasing the overall sustainable productivity of the "forest." Integration of scientific disciplines will become increasingly more important in future years as we tackle the problems of the marginal production environments as well as the more intensively cultivated production environments. This requires a research approach that recognizes and appreciates the need to have teams of scientists with different and complementary professional skills, and that attempts to be sensitive to the broad range of factors affecting productivity.

The development of a modern economy based on the application of science and technology depends on large numbers of educated people and on institutions (both private and government) through which the knowledge, experience, and energy of people can be effectively mobilized. CIMMYT's commitment to training must continue to be steadfast. In the development of new research leaders, we should not forget that the actual physical

performance of a task is the best ways to gain mastery over it. And without truly understanding a research task, one is less qualified to guide others in its performance.

Our friend and colleague, T. W. Shultz, underscored the importance of the organizational research structure in a paper he delivered several years ago in Chile. Permit me to quote his statement, "I am convinced that most working scientists are research entrepreneurs. But it is exceedingly difficult to devise institutions to utilize this special talent efficiently. Organization is necessary. It too requires entrepreneurs. But there is the ever-present danger of over-organization, of directing research from the top, of requiring working scientists to devote ever more time to preparing reports to "justify" the work they are doing, and to treat research as if it were some routine activity...In the quest for appropriations and research grants, all too little attention is often given to that scarce talent which is the source of research entrepreneurship. The convenient assumption is that a highly organized research institution firmly controlled by an administrator will perform this important function. But in fact a large organization that is tightly controlled is the death of creative research."

I would add a caveat to this statement, and that is that research, while a necessary condition, does not automatically lead to more efficient food production systems. I believe that we have a professional and moral responsibility to see to it that proven research results are used to benefit society. While we should be careful and thorough in our research efforts, we should not become overly timid. It is a characteristic of science that the perceptive researcher often sees the answer before he has all the proof in hand; sometimes, we should be willing to push for the adoption of research results, even though all of the jigsaw pieces of the production puzzle are not in place. That is where the creative research integrator comes into the picture.

I must caution here that I am concerned about CIMMYT moving away from a production orientation in its research organization. While I accept that the center cannot be involved extensively at the grass roots level in production-oriented research in the 100 plus countries it attempts to serve, it is essential that the center staff view impacts on farmers' fields as the primary measure by which they judge the success of their research efforts. Ways to maintain contact with the producer are essential to keep program priorities on track and in maintaining the practical orientation of the center. Moreover, it mitigates the erosive effects of the dangerous institutional viruses of affluency and over-sophistication.

And to the CIMMYT staff and their families. I would like to end my presentation with this thought. The destiny of a scientist, briefly stated, is to learn about, to discover, and to communicate. Excellence of each of these elements is essential to the success of science. The profession we have chosen is not for the faint-hearted; it demands involvement; it cannot be delegated very far. While CIMMYT's new training, conference, and information building, named in my honor, can increase the effectiveness of the center's work, it is only a means and not an end in itself. We must judge our worth, not by the facilities that we have or budgetary resources, by what we have contributed to the improvement of agricultural productivity in environmentally sustainable ways in the Third World. I can think of few causes more noble. May God bless and speed you in this vitally important work.

CIMMYT'S WHEAT PROGRAM OVERVIEW

Byrd C. Curtis[1]

Introduction

In this overview, I will discuss the goal, organization, philosophy, major breeding strategies, and future program objectives of the CIMMYT wheat program.

The wheat program conducts its activities within CIMMYT's broad mandate "to promote and carry out, nationally and internationally, programs to improve all aspects of maize and wheat production," and strives to contribute its share toward attainment of CIMMYT's institutional goal, which is to improve the productivity of the human, natural, and institutional resources committed to maize and wheat production.

The basis of CIMMYT's breeding programs in bread wheat, durum wheat, and triticale existed in Mexico before CIMMYT's founding in 1966. Bread wheat breeding is now entering its 44th year in the country. The first efforts in durum wheat breeding started in the early fifties, but there was no major work until the late sixties. Triticale breeding began in 1965. CIMMYT's wheat program conducts research on these crops at headquarters and in regional and national programs. It views its role as improving wheat production in developing countries and assisting in the development of national wheat research programs.

CIMMYT's Goal

Our goal is to continually develop widely adapted input-responsive bread wheat, durum wheat, triticale, and barley germplasm, primarily for distribution to the developing countries and to assist those same countries in the development of national wheat research programs. The CIMMYT-developed wheat germplasm varieties generally are photoperiod insensitive, disease resistant, and tolerant to environmental stresses.

Today more than 45 million hectares (ha) in the developing world are planted to high-yielding varieties (HYV's) and most of these are direct from or have CIMMYT germplasm in their pedigrees. Another 15 million ha of such wheat is being grown in the developed world.

How the CIMMYT Wheat Program is Organized

In Mexico, the program is organized into commodity breeding and base research support. The outreach program is divided into regional and bilateral programs. The crop programs are further subdivided into bread wheat, durum wheat, triticale, and barley. International Center for Agricultural Research in the Dry Areas (ICARDA) staff stationed at CIMMYT conduct the barley program. Research support includes germplasm development, germplasm bank, international nurseries that distribute the products of our programs, a training program, agronomy program, industrial quality, seed health, and wide crosses. Pathology is a special activity of support to all breeding programs. The regional programs are located in the Andean region, the southern cone, north and west Africa, the Middle East, eastern and southern Africa, and south and southeast Africa. We have scientists in all of those regions at the present time. The bilateral programs are in Peru, Turkey, Pakistan, and Bangladesh.

In 1985, the wheat program funds were divided into 63 percent unrestricted, 20 percent restricted, and 17 percent extra core. Core unrestricted funds can be used to support any

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[1]Director, CIMMYT Wheat Program. This chapter was extracted from a transcript of his meeting presentation.

core research activity at our discretion within the mandate. Core restricted funds may be used to support only specific core research activities. Extra core funds are those used to conduct special projects, such as bilateral and some regional projects.

Key Breeding and Development Strategies

Shuttle breeding and multilocation testing, key strategies that come into play for all four breeding programs, are described below.

Shuttle Breeding

The centerpiece research methodology used by all three programs is the shuttle breeding concept established by Norman Borlaug in the late forties. He crossed, screened, and selected germplasm during winter and summer cycles each year at two diverse locations, Ciudad, Obregon and Toluca, Mexico. Today, the winter cycle still takes place at the Mexican government's Northwestern Agricultural Research Station (CIANO), an irrigated desert environment near Ciudad, Obregon in the state of Sonora at 27.2oN latitude, 39 m elevation. Here, breeding materials are crossed and resulting progenies are evaluated for their yield potential under high fertility, well watered situations, and reduced irrigation, as well as screened for resistance to leaf and stem rusts. Samples of germplasm selected for quality evaluations are also taken from material grown at this station. Plantings are made at CIANO in November and early December. Selection and harvest are completed by early May. Seed harvested at CIANO is "shuttled" for May and June planting at the beginning of the summer cycle at CIMMYT's research station in the central highlands near Toluca (elevation 2,640 m and 19oN latitude) and headquarters at El Batan (elevation 2,240 m and 19oN latitude). At Toluca, breeding materials are also crossed and the germplasm is screened for resistance to all three rusts, as well as to septoria tritici blotch, septoria nodorum blotch, alternaria leaf blight, fusarium head scab, and bacteria such as Xanthomonas campestris pv. translucens and Barley Yellow Dwarf Virus (BYDV). Only limited yield and quality evaluations are made with the material grown at Toluca because of the extremely high disease pressure. At El Batan, germplasm is further screened for leaf-rust resistance and drought tolerance.

The basis of the broad adaptation of CIMMYT materials is insensitivity to day length. In many varieties, flowering is triggered by the onset of days of a certain length. While there are some biological advantages in certain regions in day-length sensitivity, it is usually futile to plant such varieties outside their normal growing season. Differences in day length may make flowering occur too early, too late, or if day length never reaches the critical duration, not at all.

CIMMYT's practice of producing two generations a year at different locations eliminates day-length-sensitive germplasm. From November to May, breeding and selection take place at CIANO where the crop develops as days get longer. From May to November, lines grown at Toluca/El Batan develop as the days are getting shorter. Only materials that are insensitive to this variation in day length are selected. In addition to elevation, day length, and latitude, CIANO and Toluca/El Batan differ markedly in soil type, rainfall amount and intensity, temperature, and diseases. Only those genotypes that withstand the rigors of these locations are advanced for further use in the program.

In addition to CIANO, Toluca, and El Batan, CIMMYT uses a number of "off-station" sites in Mexico. During the summer cycle, all germplasm selected in the low fertility and reduced irrigation nurseries at CIANO are further evaluated for yield potential at the semiarid Huamantla station. Also during the summer cycle, additional testing is done at Patzcuaro (for resistance to the septorias and scab) and Tepatitlan (for leaf-rust resistance). During the winter cycle, additional testing is done at Los Mochis (for tolerance to heat and leaf-rust

resistance), Rio Bravo (leaf-rust resistance), Poza Rica (helminthosporium resistance), and Bajio (agronomic type and resistance to stripe rust).

The shuttle breeding technique that has proven to be so effective in Mexico is also working extremely well on an international basis. The best example is CIMMYT's collaboration with Brazilian scientists, which began in 1973. This project's goal has been to develop high-yielding wheat varieties with tolerance to aluminum-acid soil conditions. Several low-yielding Brazilian wheats with outstanding tolerance to high levels of soluble aluminum were initially crossed with several high-yielding, broadly adapted Mexican semidwarf wheats that were highly susceptible to aluminum toxicity. The segregating populations were grown at three acid-soil locations in southern Brazil, and the selections were shuttled between Brazil and CIMMYT's main breeding sites in Mexico.

Strong selection pressure for tolerance to aluminum toxicity was applied in each Brazilian location, and selections were made for good agronomic type, stem and leaf-rust resistance at CIANO and for all three rusts and a complex of leaf diseases in Toluca. In recent years, nine cultivars obtained through this selection method have been recommended for cultivation in several Brazilian states.

In response to requests from the Chinese Academy of Agricultural Sciences, CIMMYT has also begun a small-scale shuttle breeding program between Mexico and China to develop scab-resistant spring wheats for the Yangtze River Valley and to improve winter wheat germplasm appropriate for conditions prevalent in northern and central China.

International shuttle breeding projects have recently been expanded to include Kenya and Ethiopia (resistance to the rusts) and Nepal (helminthosporium resistance). A further expansion of shuttle breeding is envisioned for the immediate future, for example, Paraguay (heat tolerance) and Morocco (drought tolerance).

Multilocation Breeding and Testing

CIMMYT wheat and triticale germplasm is developed for high-yield potential, broad adaptation, and resistance to three principal wheat diseases--stem rust, leaf rust, and stripe rust. The accretion of these characteristics in CIMMYT-developed germplasm is a direct result of multilocational breeding and testing.

Advanced generation breeding materials that have passed the rigors of selection at all locations in Mexico are yield-tested at CIANO during the winter cycle. The best performing genotypes are then entered into nurseries for international testing and distributed to cooperators around the world. In 1986, international bread wheat nurseries from CIMMYT were grown in 199 sites in 88 countries; durum wheat nurseries were grown in 62 countries, and triticale nurseries were grown in 79 countries.

Results from these nurseries provide information on adaptive ability, yield performance, and resistance to the major diseases of a broad spectrum of germplasm. These data are used to further improve the genetic characteristics of CIMMYT germplasm for a wide range of traits. It is our belief that a great deal of the success achieved by CIMMYT germplasm is the direct result of multilocation testing--in fact, it is one aspect that few breeding programs in the world enjoy. It is undoubtedly the key reason for the widespread adoption of CIMMYT's germplasm in developing and developed countries.

Breeding for Disease Resistance

One of the central objectives of the CIMMYT bread wheat, durum wheat, and triticale programs continues to be the development of disease-resistant germplasm for worldwide

distribution. Success in breeding for disease resistance is heavily dependent on international multilocational testing. The international nursery system permits the exposure of materials to a wide range of virulence for the different diseases. Performance data returned from cooperators are used to calculate the average coefficients of infection (ACI) for various diseases in numerous locations.

For rusts, a line that shows a consistently low ACI at diverse locations is presumed to carry multiple genes for resistance. Lines with low coefficients for rusts and other diseases are used in simple and three-way crosses to pyramid the resistance genes. The segregating progeny are then exposed to as many diseases as possible in the field to eliminate those that do not have broad resistance. When germplasm combines broad-based disease resistance with production potential, it is returned as advanced lines to national programs for retesting, further selection, or possible release.

Dr. Norman Borlaug and his team emphasized resistance to stem rust in the fifties and sixties, because it was the disease causing great problems. Then in the seventies the emphasis shifted to leaf rust, stripe rust, and septoria leaf blotch. In the eighties, our efforts have expanded to include helminthosporiums and fusarium scab.

Today's CIMMYT spring bread wheat germplasm has a good level of stem, leaf, and stripe rust resistance and tolerance to septoria leaf blotch in some sub-sets. Progress has been made on incorporating resistance to helminthosporium and fusarium scab, but much work remains to be done.

Aid in Priority Setting

The information returned by the cooperators also helps CIMMYT to plan future crosses as well as set the priorities and direction of the three programs. This research methodology, using the information derived from the international nurseries in CIMMYT's crossing program in Mexico, followed by the selection of superior advanced genotypes at testing sites in Mexico and other locations, has proved to be an extremely effective breeding strategy for the bread wheat, durum wheat, and triticale programs.

This approach to breeding permits timely response to changing circumstances and priorities. It also enables the rapid development and distribution of new germplasm that reflects the needs and realities of national programs around the world.

Germplasm for Megaenvironments

The research priorities adopted by the bread wheat, durum wheat, and triticale programs are shaped by the exigencies of crop production in certain large target areas. As seen by CIMMYT, each of these target areas, termed mega-environments, comprises more than 1 million ha worldwide. Megaenvironments are based on the main varietal characteristics needed by local farmers. They are relatively uniform in moisture, soil type, temperature regime, and biotic stresses. Each breeding program emphasizes broad adaptation within these megaenvironments.

Significant mega-environments are usually found on more than one continent. For example, the durum wheat program deals with a semiarid megaenvironment that includes such locations as northern and southeastern Argentina, central Mexico, central and southwestern Morocco, central Algeria, southern Cyprus, central India, and China near Mongolia and Xinjiang.

The megaenvironments for which the wheat program develops its materials comprise the following areas in which wheat is a major food crop or its consumption is rising quickly:

1) Well watered areas, generally irrigated;
2) Rainfed areas (more than 500 millimeters (mm) annually) with potential drought stress;
3) Rainfed, semiarid areas, occasionally-drought stressed (350-500 mm annually);
4) Rainfed, drought-stressed areas (less than 300 mm annually);
5) Acid soil areas where wheat production is limited by aluminum and other mineral toxicities or deficiencies; and
6) Warmer areas where sudden increases in temperature are common.

Priority Regions

Priority regions for our breeding programs are the following:

1) North Africa and Middle East comprise roughly 15.5 million ha, largely in Turkey, Algeria, and Morocco. Constraints of this priority area are stripe rust, leaf rust, stem rust, and drought.
2) Eastern and Southern Africa. There is not a great deal of wheat except in Ethiopia (600,000 ha and increasing). Kenya has been pretty stable at about 100,000 ha. The constraints are stem rust, leaf rust, septorias, helminthosporium, and acid soils.
3) Asian subcontinent. This region has 31 million ha in wheat (22 million in India, 8 million in Pakistan, and rest in three other countries). Main constraints are leaf rust, stripe rust, stem rust (not much of a problem), Karnal bunt, loose smut, alternaria diseases, short-growing season, and the drought problem.
4) Southern Cone of South America. Countries without soil aluminum problems are Argentina, Chile, Uruguay, and Paraguay. There are almost 7 million ha in wheat, largely in Argentina. Constraints include the three rusts, septoria leaf blotch, occasionally fusarium head scab, bacteria, and drought. In the Southern Cone, Brazil has more than 1.7 million ha of acid soils now producing wheat (with more expected) where the primary problem is a toxic level of aluminum in the soil which adversely affects the wheat crop. Constraints include stem rust, leaf rust, septorias, fusarium head scab, aluminum toxicity, low phosphorus availability, and drought.
5) Andean Region. Not much wheat is grown, but for many resource-poor farmers, it is an important crop. Constraints include stripe and leaf rusts, various root diseases, insect problems, high temperatures in low elevations, and poor soils in much of the highland areas (poor fertility and some acid soils).

Future Program Projections

Maintenance Research

As indicated earlier, a majority of the wheat program resources is allocated to bread wheat activities. We anticipate that this level of support must continue because bread wheat predominates in the developing world and a large proportion of the total resources allocated are involved in maintenance research, that is, maintaining advances already made. This type of research is essential for continued output of improved germplasm leading to varieties with high-yield potential and good resistance to the prevalent diseases. Pathogens causing diseases tend to mutate rapidly, thereby, rendering previously resistant varieties susceptible to the new virulences. It is impossible to calculate accurately the amount of resources allocated to the wheat program's maintenance research, but undoubtedly it more than doubles the amount dedicated to germplasm improvement.

Maintenance research is less important in the durum wheat and triticale programs because, at their current stages of progress, more resources are needed to achieve what already has been accomplished in the bread wheat program. Intensive developmental activities will be required in the medium term to develop germplasm that has broad adaptation, high-yield potential, and resistance to the major diseases. Once this has been achieved, more resources will be shifted to maintenance research and less will be devoted to development.

Shifting Priorities and Resources

The wheat program anticipates a greater research input for the world's marginal wheat areas. As more resources are allocated to the marginal environments, additional biotic and abiotic constraints will be identified. And as has occurred in the past, the identification of new constraints will require CIMMYT to shift its priorities.

For example, when farmers started growing wheat in the acid soils of Brazil with its inherent levels of free aluminum, the toxicities that were present depressed yields. CIMMYT responded by shifting resources toward the development of aluminum-tolerant wheats. To help farmers in more tropical countries, CIMMYT has initiated a program to develop wheats with better heat tolerance and resistance to the prevalent diseases. Currently, CIMMYT is giving more attention to tolerance to drought and heat and resistance to scab, helminthosporium, and BYDV. However, in the future, we may be confronted by new problems caused by abiotic or biotic stresses that will significantly affect wheat production. When this happens, CIMMYT will be ready to shift priorities and resource allocations accordingly.

Crop Management

The CIMMYT wheat program expects to give additional support to crop management. It is evident that improved production technologies must be developed for and adopted by farmers in many developing countries before the genetic potential of the available varieties can be fully exploited. CIMMYT believes it has a role in this activity and will commit the necessary staff and financial resources to achieve this objective within the context of the program. Resource allocation to crop management research will likely increase during the next decade, particularly in the regional and bilateral programs as we attempt to post crop production specialists in each region.

Training National Scientific Staff

Another vital component of the development of national research programs is scientific staff training. CIMMYT has committed a large proportion of its staff and financial resources to training for many years and will continue to do so. As the number of cooperating countries grows (for example, nontraditional wheat countries), there is a great need to train scientists because most of these countries lack trained wheat researchers. Of course, there are still training needs within the established research programs because of staff turnover and priority changes.

Current training activities in crop improvement will probably satisfy national program requirements, but training in crop production techniques needs to be expanded. With existing staff and financial resources, it is impossible to satisfy these needs and CIMMYT must work with other organizations (such as advanced national programs) to provide required production training. CIMMYT must also seek means of multiplying the effect of its training courses by using in-country training, workshops, and conferences.

Shifting Research to Developing Countries

Several of the more advanced countries within the developing world (such as India, Argentina, Pakistan, Turkey, Brazil, and Mexico) have a large number of trained staff members and well organized research programs. CIMMYT will make every effort to develop more partnership research projects with the national programs of these countries. These projects will be tailored to the specific strengths of the various national programs and to their priorities. Going one step further, some of the collaborative research, currently being conducted by research institutes in the developed world, may soon be shifted to institutes in the developing world.

More Shuttle Breeding

The wheat program hopes to develop more extensive shuttle breeding relationships with selected countries. The shuttle program with Brazil has been extremely successful and has benefited not only Brazil but also CIMMYT's effort to develop better germplasm for other countries. The efforts underway with China, Nepal, and Paraguay should yield similar results in the near- and mid-term. Another shuttle program is planned with Morocco. New shuttle breeding programs will undoubtedly be established because this method allows CIMMYT and the cooperating country to develop germplasm with a combination of traits that would be impossible if only one site were available for selection. This combination of traits is frequently beneficial to other countries as well.

Additional Networks

The core of CIMMYT's wheat program revolves around its international nursery network. This network has provided valuable information to CIMMYT breeders and pathologists and has greatly facilitated the development of germplasm that is grown in most developing countries. This network has also been highly beneficial in developing a team of wheat researchers who have worked together to resolve common problems.

With the success of this particular network in mind, CIMMYT is trying to develop additional networks for other research priorities. A recent example is the BYDV network of developing and developed countries of which CIMMYT serves as the "hub." Efforts are also underway to develop pathology networks for research on rusts and scab, helminthosporium, septoria, and bacterial diseases. A rice-wheat production management research network is in the planning stages for South and Southeast Asia to solve the problems affecting yield sustainability. Other disease networks can be added as priorities change.

Disease Surveillance Program

Since the seventies, CIMMYT has conducted a disease surveillance program. This network of cooperators has helped monitor and survey prevalent diseases and races that exist throughout the world. Preliminary results of the survey have been distributed to cooperators, and during 1987, complete data from the program will be published. The results should help us identify epidemiological zones around the world. We should also obtain some insight on the dissemination of new races from one country to another.

These results have been obtained with very limited resource input. Since diseases are an important constraint to wheat production in most areas of the world, we believe that additional resources should be given to this activity. In 1987, CIMMYT assigned at least 0.5 scientific man years (SMY) to disease surveillance.

Biotechnology

We believe biotechnology holds promise for the future although little of the new technology is presently applicable to wheat. New methodologies will undoubtedly be perfected that will improve the efficiency of developing germplasm and provide an additional tool in pathological research. When these tools become available, the wheat program will make every effort to incorporate them into the research effort. If additional resources are needed, priorities will be adjusted to accommodate the requirements.

Conclusion

The CIMMYT wheat program has been underway since 1944 when Norman Borlaug was assigned to the Office of Special Studies in Mexico with funding from the Rockefeller Foundation. The name CIMMYT (acronym for Centro Internacional de Mejoramiento de Maiz y Trigo) was adopted in 1966.

During the next 42 years, wheat germplasm was developed which, along with the new rice germplasm from IRRI, lead to the green revolution in the late sixties and early seventies. A philosophy of wheat germplasm development and methodologies emerged that have resulted in tremendous gains for wheat farmers in the developing and developed world. These activities are continuing but with a shifting of resources to include more marginal wheat production areas.

CIMMYT'S MAIZE PROGRAM OVERVIEW

Ronald Cantrell[1]

Introduction

I will first give you a brief overview of the maize program as it is now and then indicate some of the areas in our research program that are likely to change in the future.

The objective of our maize program is to facilitate maize research in Third World countries. We do so by providing national maize programs with improved germplasm and other products and services such as research procedures, training, and technical information. These are developed and delivered by some 15 scientists working at our stations in Mexico and by an equal number of maize researchers involved in regional and bilateral programs outside of Mexico. The ultimate aim of our research is to increase the options available to farmers for raising the productivity of resources that they commit to maize production. In working toward that goal, we give the highest priority to our relations with national programs. We also take an active interest in the work of other organizations such as universities and private seed companies whose research results in products that can help farmers increase the efficiency of their maize production.

One extremely important part of the CIMMYT maize program is our variety development scheme. Our system has a funnel-shaped structure very similar to that of any other large breeding program for a major crop. At the top of the funnel is the area of the greatest genetic diversity. As you move down the funnel, genetic diversity is decreased and uniformity is increased. You would find this to be true whether you are breeding for a hybrid program or, in this case, a variety development program. At the wide end of the funnel is our germplasm bank in which we maintain a little over 10,000 accessions.

Drawing on these genetic resources from the germplasm bank, the program formed a large number of gene pools or germplasm complexes. Each gene pool is adapted to one of several broad regions we refer to as megaenvironments. An example is the lowland tropics. Megaenvironments encompass many smaller growing areas that are distinct from one another in some respects but similar in elevation, climate, and other features that affect the maize germplasm requirements. The gene pool subdivided by maturity, grain color, and grain type is improved in our backup unit by means of half sib family selection procedure.

Correpsonding more or less to these pools are a number of more elite germplasm material. Within our advanced unit, those materials are placed under more intense selection pressure in a modified full sib family selection scheme that includes international testing. Selected families of full sib progenies are evaluated at up to six different locations in the first testing stage. Based on these test results, we form an experimental variety which is then distributed to national maize researchers for evaluations at 30-50 strategically chosen locations. The best performers in these trials, which we term elite varieties, are then tested at 60-80 other sites.

One of the attractive parts about our program is that the national programs take a great deal of pride in forming these varieties. They consider it their work if they are involved in forming varieties. They do not take nearly as much pride in releasing varieties that have been selected by others straight out of the variety trials. The varieties emerging from our breeding program are by and large intermediate rather than finished products. They generally

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[1]The author is director of the Maize Program, CIMMYT.

are not adapted to a particular ecological niche but rather to a megaenvironment. For that reason, they must undergo a certain amount of adaptive testing before they can be released to farmers.

In the development and delivery of intermediate research products, using the most appropriate techniques can be almost as important as the best available germplasm. For that reason, we devoted a large portion of our time and resources to developing improved research techniques. This makes our program more efficient and also helps national programs in conducting their research and applying their research more effectively to meet farmers needs. Some examples are techniques for mass rearing, artificial infestation with insect pests for resistance screening, and breeding methodologies for developing improved varieties.

The set of techniques that have proven especially useful to national program are ones CIMMYT scientists developed for onfarm research. National scientists examine farmers' circumstances, identify production problems, and carry out experiments to resolve those problems under conditions of the representative farmer. At CIMMYT, we convey ideas about onfarm research through our in-service and in-country training programs. The majority of maize program trainees participate in one of our 5- to 6-month, in-service training courses. The courses cover production agronomy, maize improvement, protein evaluation, and experiment station management, and are held at CIMMYT's headquarters in Mexico.

Other trainees come to the center for a week to several months as a visiting scientist to familiarize themselves with our breeding and other programs. A smaller number of predoctoral fellows who have finished their university coursework may conduct their thesis research under supervision of CIMMYT scientists. We also have positions for post doctoral fellows who become more closely involved in the research program while still working independently on a problem of special interest to them. Training is not provided indiscriminately but in a very deliberate manner. It is based largely on the information that we receive from our regional programs. We recently gave a lot of thought to those programs and tried to clarify and describe their functions with greater precision. One important point that has come out of this effort is the tremendous value of the regional program as an information link between our international client countries and CIMMYT headquarters staff in Mexico.

Our regional programs also enable us to provide stronger support for research planning in national maize programs. The planning approach we promote in our regional programs resembles that used in private seed companies. We first encourage national researchers and administrators to identify specific product needs. Since onfarm research is the best way to identify those immediate needs, we will continue to spend a lot of time helping maize scientists make this type of work a permanent feature of their research program.

Once product needs are identified, we work with the national scientists in planning research and allocating resources for products that nation's farmers need. It would hardly be appropriate for maize program staff to preach such a doctrine without following it to the letter. That is why we are now engaged in a priority-setting and planning process. I would like to further develop our effort to gather more detailed information on the germplasm requirements of maize-growing environments in the third world.

For selected countries such as Ghana, we are delineating megaenvironments by compiling general information about maize production around the country. Our regional staff and their colleagues in national programs supply most of this information. They determine demand for maize farmland, time for maize to mature on that land, and so forth. In addition to recording the general features of maize production in a given environment, we are trying to learn more about the extent and severity of specific problems as disease and insect pests.

Our ultimate goal is to gain a clear idea of germplasm needs throughout the developing world. The next step would be to improve our capacity to meet those germplasm needs with greater

accuracy. The exact details are now under consideration, but we do have a general idea of some expected changes in the following five areas: the germplasm bank, the backup unit, the advanced unit, the new hybrid maize program, and the maize physiology program.

Germplasm Bank

The first thing we would like to do is to better store the germplasm resources that we have. We have built better long-term storage facilities so that the seed can be stored longer. Thus, less regeneration time will be required. We are also trying to set up a computerized data storage and retrieval system that will enable us to efficiently store and retrieve information quickly when people make requests. We are also developing training materials so that people are better aware of what is available in the germplasm bank and how it can be used. In addition, we are trying to set up a maize germplasm network of individuals who would preserve maize germplasm.

Mexico is the center of maize origination. One of the services that we would like to provide, in conjunction with the Mexican national program and some of our U.S. collaborators, is monitoring of these wild populations. We will make annual visits to determine whether or not significant changes are occurring in the wild population. We know that there is one race of maize around the Mexico City Valley that is almost extinct. We want to make sure that this does not happen to other races. We would also like to do research on some of the land races. We know from earlier research that there are certain heteorotic patterns that develop among some of these superior land races. We would like to try to reconstruct them. In this way, we can obtain some new and different germplasm for our breeding programs.

Backup Units

The original objective of the backup unit was to be a next step beyond the germplasm bank. We wanted to have complexes containing broadly adapted germplasm that would have great genetic diversity. We also had the objective of providing superior germplasm for our more advanced populations. We are finding that those two objectives are somewhat juxtaposed. It appears that high degree of genetic diversity cannot be maintained while simultaneously providing elite germplasm from that pool. Thus, we are redefining what we do in the backup unit. We will continue to generate and maintain widely adapted germplasm pools as sources of genetic diversity.

We plan to identify germplasm needs for specific traits. We will generate a pool that, for example, has resistance to a specific disease or insect. We call these special-purpose pools. We are moving in this direction because in the past we tried unsuccessfully to generate pools with specific resistance by taking into consideration selection for insect pests as well as yield, disease resistance, logging, and grain quality and characteristics.

Advanced Unit

Many similar opportunities for improving efficiency have arisen in the advanced unit. To take advantage of them, we are considering an approach roughly parallel to that of the backup unit. A large number of populations are now being improved in the advanced unit. Experimental varieties are developed from each population and tested internationally. Populations are given equal emphasis and are handled according to the same breeding methodology.

The new approach being considered is to reduce the total number of populations and divide them into two groups, infinite-life and finite-life populations. The infinite-life populations, of which there would be one for each ecology/grain type and color/maturity category, would include populations already in existence and perhaps some new ones. As their name implies, these populations would be open-ended. For the next 10 years or so, or until better materials were found to replace them, they would continue to receive new germplasm. They would be improved by the same modified full-sib recurrent selection scheme now in use and would be tested internationally under the International Progeny Testing Trial (IPTT) system. By working with a smaller number of the infinite-life populations, we can devote more attention to solving problems as disease and insect pests that are specific to particular regions of the world.

The finite-life populations would primarily be used to focus on these problems. The original development and improvement of the finite-life materials could be carried out by national program scientists, regional maize staff, the backup unit, or other CIMMYT maize program units. These groups could use whatever methodology seemed most appropriate to solve the region-specific problems at hand. If the materials they produced showed enough promise, they could be proposed as finite-life populations, and, if accepted, would enter the IPTT system. These populations would be improved within the IPTT system for no more than two cycles and then be returned to their originators. This approach's chief advantages is that it would sharpen the focus on region-specific problems, allow researchers to use a variety of breeding methodologies, involve national scientists more fully in developing better germplasm, and improve the mechanism for delivering that germplasm to national programs.

The New Hybrid Maize Program

All of the changes I have described involve modifying systems already in progress at the CIMMYT maize program. The last topic to be covered is an entirely new effort at headquarters to serve national researchers interested in the development of maize hybrids.

In the past, the maize program had no systematic means of helping those researchers. But for a number of reasons, it is considered appropriate and necessary to expand CIMMYT's capacity to support hybrid work. Foremost among those reasons is that a growing number of national programs are interested in and have the capacity to develop maize hybrid. In cases where hybrid development is considered potentially successful, our aim is to help national programs go about this task in an efficient and cost-effective way.

CIMMYT has now established its own hybrid program, which will cater to the needs of national hybrid development efforts in several ways. It will compile information about inbreeding depression and heterotic patterns for both gene pools and populations. It will also select superior materials from improved pools and populations. They will be taken through several generations of inbreeding and then be made available to national programs. Plans are also underway to provide national researchers with detailed information and training in various techniques of developing hybrids.

Much of CIMMYT's effort in this area will be devoted to the so-called nonconventional hybrids for two reasons. First, there is little published material on how to develop family, topcross, and variety hybrids, and it would be worthwhile to try to fill this information gap. Second, because these types of hybrids are much easier to produce than the conventional ones, they should provide better options for many developing countries that have started or expect to start hybrid programs.

Maize Physiology Program

We think that there will an increased role and emphasis on our maize physiology program. The major areas that progran staff will address are with general stress tolerance, efficiency of nitrogen use, and tolerance to aluminum toxicity. The major role that physiology plays is to help us identify selection criteria that would make our breeding more efficient. For example, it could help us isolate a particular trait that increases the rate of genetic gain. One of the major constraints in developing countries is drought. For example, many areas of West Africa get up to 1,200-1,300 millimeters of rain during growing season yet report yields of only 1-2 tons. The major problem is the rainfall distribution. Drought associated with stand establishment is a very serious constraint in many of these areas.

Conclusion

This overview reflects current operations, but is not necessarily the description CIMMYT staff members would have given 10 years ago. Nor is it likely to be the one they give several years from now.

The CIMMYT Maize Program has made important adjustment. It will continue to respond to changing circumstances and new opportunities for achieving greater efficiency. Thus, what we now contemplate is not a different program, but only the next step in its development. Among the important developments of its 20-year history were the initiation of the international testing network and the creation of the regional program in 1974. It is hoped that the changes we are now considering will be just as beneficial to agricultural progress in the developing world.

SPECIAL ISSUES IN TRADE AND DEVELOPMENT

THE ERS TRADE LIBERALIZATION STUDY: METHODS AND PRELIMINARY RESULTS

Nicole Ballenger[1]

Background

The ERS trade liberalization study began to take shape in mid-1985 at the initiative of Bob Thompson, Assistant Secretary of Agriculture for Economics. The major objectives of the study are: (1) collect international agricultural policy data and conduct policy analysis for U.S. policymakers and negotiators as they prepare for a new round of multilateral agricultural trade negotiations (MTN), and (2) to provide information to the public and contribute to the public debate on agricultural trade liberalization. As it pursues these objectives, the Economic Research Service (ERS) is accumulating a capital stock of models and analytical expertise that can be called upon as the MTN process continues.

The trade liberalization study has followed two main courses since its inception: (1) measuring Government support to agriculture using the concepts of the producer subsidy equivalent (PSE) and the consumer subsidy equivalent (CSE), and (2) developing a static world policy simulation model (SWOPSIM) to analyze the effects of reducing or eliminating Government agricultural support. Policymakers at the U.S. trade representative's office and the Foreign Agricultural Service recently asked study participants for help in understanding how PSE's and CSE's could be used as part of the MTN bargaining framework.

Producer and Consumer Subsidy Equivalents

The decision to use PSE's and CSE's as the measure of Government support to agriculture allowed ERS to build on work conducted at the Organization for Economic Cooperation and Development (OECD). The OECD trade mandate study estimated PSE's and CSE's of OECD countries for 1979-81. The ERS study includes OECD countries and a number of developing countries important in agricultural trade. The initial ERS study period was 1982-84.[2]

The PSE is defined as the level of subsidy that would be necessary to compensate producers in terms of revenues for removing all Government support under current programs. The CSE is defined as the payment that would be necessary to compensate consumers for removing all Government support under current programs. PSE's and CSE's differ from measures of producer and consumer surplus because they do not account for policy-induced changes in production and consumption. That is, PSE's and CSE's are measured at observed levels of production and consumption. This characteristic of PSE's and CSE's is shared with well-known measures of protection such as the nominal rate of protection (NRP) and the effective rate of protection (ERP). PSE's are typically reported as ratios between the value of Government support to producers and the value of production in order to compare support levels across countries or commodity markets. CSE's are reported as ratios between the value of Government support to consumers and the value of consumption at a designated point on the marketing chain. PSE's and CSE's can be positive (implying a subsidy) or negative (implying a tax).

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[2]Countries included in the ERS study are the United States, the European Community (EC), Canada, Japan, Australia, New Zealand, Taiwan, South Korea, India, Brazil, Australia, Mexico, South Africa, Nigeria, Thailand, Indonesia, Sudan, and Egypt. Commodity coverage varies among countries.

The ERS study incorporates a broad array of Government policy instruments in the PSE and CSE analysis. It includes the following categories of policies:

- o border measures and domestic price support programs;
- o direct income payments, including payments from Government to producers and payments from producers to the Government;
- o farm input, credit and marketing subsidies;
- o programs affecting agricultural production in the longrun, such as research and advisory services;
- o exchange rate controls, such as fixed, multiple, and pegged rates.

CSE's contain the components of PSE's that directly affect prices paid by consumers relative to world prices, border measures, many domestic price support programs, and exchange rate controls.

Current ERS estimates of PSE's and CSE's do not include policies administered by States, provinces, or the National Governments of the EC; export credit programs; and food stamp programs. There is no attempt, in calculating PSE's, to adjust the estimates to account for the effects of supply management or acreage reduction programs on farmer revenues.

Two main approaches are used to measure the subsidy equivalent of Government support: (1) allocating the net Government expenditures for a program among commodities affected by the program; and (2) calculating the effect of a program on the domestic price relative to some reference price and applying the amount of this price wedge to the total amount of production or consumption. Although there are standardized approaches to measuring the subsidy equivalents of similar policies in different countries, the development of each PSE is tailored to the policy profile and data sources of each country and commodity market within that country.

Preliminary Results

The PSE analysis indicates that exporting countries tend to provide less assistance than importing countries to producers of a particular commodity; that food grain, sugar, and dairy producers tend to receive higher levels of assistance than other producers, particularly nonruminant meat producers; and that negative rates of producer assistance are sometimes found in developing countries. When aggregate PSE's--that is, the weighted averages of commodity-specific PSE's--are calculated for each OECD country included in the study, they indicate the following ranking for 1982-84: Japan (70 percent), EC (41 percent), Canada, United States, and New Zealand (20-25 percent each), and Australia (6 percent). In other words, the ratio of Government assistance to total producer income during the period studied, was over three times greater in Japan than in the United States, while assistance in the United States was three to four times greater than assistance in Australia.

The CSE analysis indicates that in developing country CSE's are typically negative except for less developed countries (LDC's); that consumer taxes are typically highest on sugar and dairy products; and that CSE's on food grains tend to be lower than the corresponding PSE's, due to Government policies designed to mitigate the negative effects of producer price supports on cumsumers. Consumers pay dearly for producer support in the EC, Japan, Taiwan, and South Korea. Most U.S., Australian, Canadian, and New Zealand CSE's are low, exceptions typically CSE's for dairy products and sugar.

Negative PSE's are found, in some cases, in LDC's. For example, Argentine's PSE's are negative due to export taxes. The study also identified negative rates of assistance for India, Brazil, and Nigeria. Exchange rate policies are often important in LDC's. For example, the nominal rate of protection for Mexican wheat was negative in 1982 and 1983, but an

undervalued currency in those years resulted in an implicit subsidy to Mexican producers and a net positive PSE. On the other hand, Brazil's tendency to tax its soybean producers through export taxes and quotas was reinforced through the policy of maintaining an overvalued cruzeiro.

The PSE and CSE analysis is also used to show in which countries border measures contribute to the overall level of producer support. The U.S. relies little on border measures, except to protect dairy and sugar producers. In the EC and Japan, border measures are the principal forms of support. Australia and Canada do not rely on border measures as major sources of support. The forms of domestic policies these countries use, however, differ from those the United States used. The study also indicates how differently countries distribute the cost of support to their agricultural producers among consumers and taxpayers.

Implications for Trade Liberalization

ERS analysis of Government intervention in agriculture and agricultural trade liberalization is ongoing. The results this chapter presents, which are the measures of producer and consumer subsidy equivalents for 1982-84, represent the first phase of the trade liberalization project. These results are important because they condense the array of Government policies affecting agriculture into summary measures that can be compared across countries and commodities.

PSE's and CSE's provide a way for countries to monitor and measure each others' policy changes. They also offer a possible framework for multilateral exchange of concessions on agricultural policies.

Despite their potential usefulness, PSE's and CSE's alone do not fully reveal the effects of Government involvement in agriculture on production, consumption, trade flows, or prices. PSE's in most major trading countries are positive, while CSE's are negative. They do suggest that, in the absence of Government intervention, world agricultural production would be lower and world consumption higher, leading to generally higher world price levels. This hypothesis is supported by trade liberalization analysis at the World Bank and the OECD. The actual effects of Government policies on world and domestic markets, however, cannot be known without an understanding of the response of producers and consumers to policy changes and without incorporating the effects of supply-reducing policies, such as U.S. acreage reduction programs, into the analysis.

IS THERE A ROLE FOR PRODUCER AND CONSUMER SUBSIDY EQUIVALENTS IN TRADE NEGOTIATIONS?

Nancy E. Schwartz[1]

The U.S. Department of Agriculture's (USDA) calculations of producer and consumer equivalents, termed PSE's and CSE's consist of two components.[2] Indirect and direct budget transfers to farmers, or what might be called the budgeted subsidy effect are the first kind of components. Indirect means of raising farm incomes through border measures, which put a price wedge between domestic and world prices, are the second kind. Calculated this way, the absolute value of these transfers to farmers approximates producer surplus without the deadweight welfare triangle. The CSE approximates consumer surplus.

One suggestion for possible strategies in the current round of General Agreement on Tariffs and Trade (GATT) talks is to negotiate a reduction in PSE's and CSE's, among all participants. Before such a strategy is adopted, negotiators need to be aware of potential limitations of the statistics that could prevent their use. This chapter reviews some of those limitations, focusing on PSE's.

There are some general limitations for which it is difficult to correct but which are not sufficiently large to prevent the PSE's from being used as negotiating tools. First, the policies of certain countries have a spillover effect on other countries. Perhaps the most obvious example of this effect is the U.S. loan rate. The loan rate represents a floor price to the rest of the world, and, therefore, effectively subsidizes foreign production. The effect is magnified, as we have seen in the past 5 years, when the U.S. dollar is overvalued internationally. Foreign expansion is less risky but more profitable provided that the loan rate is higher than the free-market world price (the price that would prevail in the absence of the loan rate). In a broader sense, the measures fail to take into account any large-country price effects on the world reference price. All countries are assumed to be price takers. Therefore, changes in border prices or budgetary expenditures are assumed to have no effect on the world reference price. In reality, however, a major policy change in a large country will probably affect the world price.

Second, the PSE's and CSE's have to be measured in a common currency to measure the wedge between domestic prices and a world reference price. For example, the reference price, expressed in dollars must first be translated into a domestic currency amount. PSE's and CSE's are therefore sensitive to changes in the value of countries' exchange rates compared with the dollar. As the dollar appreciates, it reduces other countries' PSE's and CSE's because it raises the world reference price. Countries that do not change their domestic programs therefore will appear to be subsidizing less if their currencies depreciate against the dollar. Even when the measures are corrected for certain types of exchange rate policies, the basic problem remains.

Third, PSE's and CSE's are subject to volatility from year to year because of changes in supply and demand, even if a country's policies do not change. For example, a bumper crop in a small country might increase the value of cash receipts relative to transfers. If the price wedge were small in comparison to budgetary expenditures, the PSE would tend to fall. By contrast, a crop shortfall might increase the PSE.

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[1]The author is an economist, Agriculture and Trade Analysis Division, Economic Research Service, U.S. Department of Agriculture, Washington, DC. These comments are a summary of a paper delivered at the winter meetings of the International Agricultural Trade Research Consortium held in El Batan, Mexico, Dec. 13-18, 1986.

[2]Except as noted, my comments are restricted to USDA numbers. The PSE's and CSE's calculated by the USDA are not always consistent with the Organization of Economic Cooperation and Development (OECD) calculations. Nor are all the OECD numbers calculated in the same manner.

In sum, the measures will vary from year to year as world prices fluctuate, as exchange rates change, and as supply and demand rise and fall about trend. This volatility suggests that negotiators will need to agree on the base year as well as on the measure. Despite these limitations, the OECD countries did agree on a base year for their trade liberalization study. Therefore, it is reasonable to expect that these measurement problems, while serious, are not insurmountable obstacles to the negotiations.

Other problems are likely to present more difficult obstacles to using the current PSE and CSE formulations in the negotiations. First, some key policies have escaped inclusion due to political or measurement problems. Export credits, for example, are excluded. Excluding such programs sends a signal that these are nondistorting programs or that these kinds of programs will not be subject to international scrutiny in the trade negotiations. Since export credits do not show up as line items in Government budgets, they signal the wave of future subsidies. Countries may infer that any program effectively subsidizes farmers without adding to the Federal or State budget (or otherwise raising the PSE) will be sanctioned, regardless of its trade effects.

A minor related point is that the measures include some expenditures such as research costs, which should be left out. The largest countries expenditures on research, in fact, have substantial beneficial spillover effects onto other countries.

The second and most serious problem with the USDA transfer measures is the weighting system. For example, the USDA measures as currently calculated, do not take supply management effects into account. In broader terms, the measures do not weight expenditures by their trade effects. Specifically, they do not weight expenditures by how much the policy package induces new production, in the case of PSE's, or shrinks consumption, in the case of CSE's. Were the current PSE's to be negotiated, a $10-million cut in research expenditures for a given country would have the same effect on the value of a PSE as a $10-million drop in deficiency payments. Trade-weighted or "effective" PSE's are needed if the negotiations are to result in meaningful cuts in subsidy levels.[3]

If PSE's and CSE's are to be used in negotiations, participants need to agree on certain technical issues. They must reach consenus on which policies should be included and, possibly, on which methodology should be used to calculate the trade, or additionality effects. For example, countries will have an incentive to undervalue their own-price supply and demand elasticities, and to assume that their elasticities of substitution are infinity.

The principal value of PSE's and CSE's is that they helps identify which policies are the major sources of protection in each country. They also determine where changes ought to be made. First, however, an effective measure or an alternative negotiating strategy that addresses the issue of additionality is needed.

Even "effective" PSE's and CSE's may not be tractable negotiating tools. Can we assume, for instance, that after comparing PSE's, individual countries will be willing to swap changes in what are essentially domestic policies for changes in another country's border measures? We are still a long way off from anticipating that outcome at the GATT trade negotiations.

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[3]Although none of the USDA numbers have been trade-adjusted, some of the OECD numbers have been. OECD transfer measures therefore are not strictly comparable across countries.

TRADE LIBERALIZATION: A CANADIAN VIEW OF GATT AND THE MULTILATERAL TRADE NEGOTIATIONS

Don McLatchy[1]

By way of background, I will begin with some reflections on the wording of the recent Punta-del-Este Ministerial Declaration. Then I will identify and briefly discuss six issues that I think should concern us.

Background

The final text to emerge from the Punta-del-Este deliberations, when viewed in the light of earlier drafts and individual country positions, probably provides some clues on which issues will arise and how agriculture is to be handled in this round.

The following features of the "Punta" declaration are interesting. The underlining is all mine:

(a) There is no reference to any "special characteristics" of agriculture. However, agriculture is still to be treated separately, with "Agriculture" being one of several negotiating groups to be set up under the umbrella of the Group for Negotiations on Goods (GNG).

(b) The agriculture negotiating group will have primary but not exclusive responsibility for agriculture.

(c) The "General Principles" call for "balanced concessions within sectors" and "avoiding unwarranted cross-sectoral demands."

(d) There is no agreed "fast track" for the agriculture negotiations, but the "General Principles" explicitly allow for the possibility of an early agreement and its implementation.

(e) All measures directly or indirectly affecting agricultural trade are to be subject to negotiations (no singling out of "export subsidies").

(f) There is reference to a "phased reduction" of the "negative effects" of subsidies (not necessarily of the subsidies themselves). No specific time frame is mentioned, but the discussion is stronger than the "possible phased reduction" referred to in an earlier draft.

Some Issues

The following issues are not in order of preceived importance.

Implications of Seeking to Balance Concessions Within Agriculture

Will this really be possible? It seems to raise problems for countries with either little to gain (such as Japan) or with little to give (such as Australia, New Zealand, and some developing countries) in the agricultural area. Hathaway has suggested that it will pose problems for the United States, too. In the past, concessions in other sectors were traded off for gains in agriculture. It appears that this time the "bargaining chips" must come from

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within the agricultural sector. Will the big players, the United States and the European Community (EC), be willing to give the "Australians" a free ride in the agricultural negotiations and at the same time exempt Japan from making agricultural concessions beyond those commensurate with the limited gains they could expect? It seems unlikely, and I expect that some formal or informal mechanism to account for cross-sectoral tradeoffs will probably evolve.

Political Will and Negotiating Credibility

These are really two closely related issues. The first question about whether the political will really exists, despite the rhetoric, to make the necessary changes, has been raised by Johnson. I think is a legitimate one for many countries, including Canada. Given that significant changes in trade-related measures (such as barriers and export subsidies) will of necessity imply changes in some domestic programs, we must ask the questions: are the politicians ready to bite the political bullet? There is no need for me to remind you that many groups within U.S. agriculture such as dairy, sugar, corn, and soybean interests benefit from the policy status quo, including current EC measures. These groups could lose from reduced protection in either or both countries. Maybe the real political battle will not be between countries but between the agriculture ministers and farm lobbies of all major countries in the "green corner" and all countries' finance ministers and central agencies "in the red" (sic).

Perhaps even more important is the credibility question, and I think it applies to the United States and the EC in particular. Will their negotiators really have a mandate to commit their countries? How seriously should they be taken? Johnson refers to "Congress's disdain for international agreements" and suggests that unless the famous Section 22 of the Agricultural Adjustment Act is repealed "Congress will force violations of any trade agreement." Certainly, I think, other countries question the extent to which the United States is willing to be bound by international agreements. This weakens the General Agreement on Tariffs and Trade (GATT).

What seems to be needed is a change in attitude away from the notion that domestic agricultural policy puts constraints on what can be agreed in the GATT (and that changes in domestic policy are valid reasons for requesting or forcing waivers and exceptions under the GATT) toward an acceptance that GATT rules put constraints on the shaping of domestic policies. I am pessimistic about whether such an attitude change is yet taking place in the political power structures of the major players.

The Relative Timing and Emphasis to Be Put on Negotiating Rules versus Specific Concessions

As I understand it, Canada and several others would like an initial phase of the negotiations to focus on strengthening the rules, with specific concessions to follow. The United States, I believe, is favoring getting straight into concessions, on the grounds that attempts to change the rules would result in only very slow marginal adjustments. The EC may want to spend the first year on further analysis, which some would see as a stalling tactic, while others may perceive a genuine need for European politicians and their electorates to be more convinced of the broader economic benefits of reduced agricultural protectionism (on the basis of comprehensive economic analysis) before being willing to make significant moves to free up agricultural trade.

In the past, the emphasis has been on specific concessions (in particular tariff reductions). Rules have been treated as somewhat subservient to concessions in that exceptions/ derogations/waivers were readily adopted if acceptable specific concessions could be found which contravened the rules. For the future, a relevant question may be "which of the two allows more scope for circumvention?"

The dominance of a few major players has allowed a focus on bilateral balancing of concessions in past rounds. I believe that, in future, with more players and less dominance, this won't work as well. A multilateral balancing of concessions would theoretically raise the potential payoff from GATT negotiations to most or all players. However, the practical difficulties of developing a satisfactory mechanism for keeping track of all the multilateral benefits to arise from a given concession (incorporating all the intercommodity and intercountry linkages which exist), and of developing a procedure for truly multilateral negotiation of concessions, are daunting. This is the main reason why I think increasing emphasis may have to be placed on negotiating (exceptionless) rules in this and future rounds.

Is the Existing GATT Structure and Mechanism Too Constraining?

It would appear that, following the proposals of the Committee for Trade in Agriculture (CTA), the approach in the Uruguay Round will be to follow already-established procedures and to work from existing GATT articles. Given the hopes and recognition of the need for substantial progress in agriculture this time around, should the starting point be closer to square one?

Most proposals to come out of the CTA seem to refer to possible changes in just two key articles; Article XI (notable for permitting quantitative import restrictions if they exist to support a supply-management policy) and Article XVI (which exonerates agricultural subsidization as long as it does not lead to an "unfair share of the world market"). No doubt, delegates who have been involved in past rounds will remember the time and effort involved in reaching agreement on the existing articles and be very reluctant to give up hard-won ground.

As they stand, Article XI is seen as essentially dealing with access and Article XVI with subsidies, and there appears to be some feeling that their further negotiation can be separated and made the responsibility of two different negotiating subgroups. Is this logical? For example, it is not feasible for a country to use substantial export subsidies without import controls, yet one of these instruments falls under "subsidies" and the other under "access." Similarly, the whole area of administered pricing seems to be treated to date as an "access" issue, yet the transfer of income from consumers to farmers via regulated prices is probably in many senses a "subsidy" affecting production and trade (and little different from a transfer from taxpayers via government expenditures).

Perhaps the time is ripe to consider the creation of some new, specifically agricultural articles, incorporating imaginative new rules extending to areas not previously touched by the GATT.

Negotiations on Levels of Subsidies, Subsidy-Equivalents, or Trade-Volume Effects

There is considerable interest at this stage in negotiating commitments to reduce levels of government intervention as measured by some broad economic indicator. The producer subsidy equivalent (PSE) concept, which has gained prominence through its use in the OECD's "Agricultural Trade Mandate" study, is most frequently referred to, but other alternatives are conceivable. The idea is attractive for several reasons:

(a) The relative simplicity of reducing negotiations to one dimension (a practical means of achieving multilateral balancing of concessions?

(b) The flexibility it would give to governments to choose the precise ways of reducing their levels of assistance or interference;

(c) A means to draw even the commodities with the most politically powerful lobbies into the scope of the negotiations.

A major subissue is what precise measure to choose. I will briefly discuss three possibilities:

(a) Levels of subsidies in the narrow sense of government expenditures or net fiscal cost. This can be dismissed quickly on the grounds that much producer support (approximately 50 percent in the OECD countries in 1979-81), and trade distortion, derives from relatively "costless" (in a fiscal sense) transfers from consumers (see also Johnson);

(b) Levels of income subsidization, - for example, PSE's

Negotiating reductions in PSE levels appears to be favored by many in the United States. The Australians are talking about something very similar, what they call the "price adjustment gap." Conceivably, the concepts of "nominal rate of protection" and "effective rate of protection" could also be candidates.

Our big objection to all these indicators is that they are measures of income support and not of volume or trade distortion (see McClatchy and deGorter). In our view, it is the latter which should be the interest and focus in trade negotiations. We recognise that if the overall level of world farm income assistance were reduced, the level of trade distortion would fall (as demonstrated recently by the OECD), but also that in particular cases the level of PSE is not a reliable indicator of even the direction, let alone the magnitude, of the associated output volume effect and trade distortion. Many examples of current policies involving relatively high PSE's and relatively low trade effects exist. Given the reasonable arguments that high-target prices, when accompanied by appropriate levels of land set-aside requirements, may do nothing to increase U.S. output or reduce world prices, I am somewhat surprised at American advocacy of this as a negotiating tool. With many European countries favoring moving toward supply management options, I doubt that the idea will appeal to them either. Note that the Punta Declaration does refer to a reduction of the negative effects of subsidies (not necessarily the subsidies themselves) and the Danish vice-chairman concluded, after a recent debate in the United Nations on trade and agricultural subsidies, that "the major tasks of the new GATT round will be to seek agreement on the impacts of subsidies, other farm support policies and trade barriers on the present distortions in agricultural trade" (my underlining).

(c) Levels of Trade Volume Impacts

A "modified" or "adapted" PSE is of course conceivable, where programs and policies would be rated in terms of their simple-subsidy-equivalency in a production- or trade-distorting sense, rather than in the income-enhancing sense of Josling's original or pure PSE concept. This would overcome our major objection, and perhaps deserves the most attention as a prospect for use in the GATT. Some serious problems and issues, both of a theoretical and practical nature, would still seem to remain, however.

In summary, I think this particular issue is one where International Agricultural Trade Research Consortium (IATRC) members, as a group or as individuals, could have a useful input into the developing GATT process.

The Extent of Use of Quantitative Economic Analysis in the Uruguay Round

This is the issue which perhaps most directly affects us as IATRC members. I refer to the use of such analysis to assist in the choice of individual countries' negotiating positions (and potentially also in the choice of negotiation subjects), both initial positions and responses to others' initiatives.

My impression (though I lack first-hand experience) is that the analysis underlying agricultural negotiating positions in past rounds was generally very limited and unsophisticated (and possibly appropriately so, given the focus principally on tariff reductions). This time I do think there is a much greater potential for the use of deeper analysis, for both supply-side and demand-side reasons, such as:

(a) The broader scope ("all measures affecting trade") and larger number of players make the net results of any potentially negotiable package of simultaneous changes much less transparent;

(b) The increased awareness (perhaps even incidence) of cross-commodity effects necessitating multicommodity analysis;

(c) the increased feasibility due to the technology (for example, microcomputers) and accumulated modeling experience we now have.

Just what type of analysis will be required depends, I think, on the resolution of some of the foregoing issues; for example, whether the rules being negotiated continue to be predominantly what Anjaria and others would call "measure-based" or whether they become increasingly "effect-based," such as may happen if negotiations on PSE reductions and, perhaps, "acceptable levels" of PSE's proceed.

Looking further ahead, after this GATT round, I think it is inevitable that there will be more call than heretofore in all countries for analyses of likely trade impacts of unilateral domestic policy changes, before such decisions are taken.

References

(1) Anjaria, S.J. "A New Round of Global Trade Negotiations," Finance and Development, Vol. 23, No. 2, World Bank, June 1986, pp. 2-6.

(2) Babcock, B., and A. Schmitz. "Look for Hidden Costs: Why a Direct Subsidy Can Cost Us Less (and Benefit Us More) Than a 'No-Cost' Trade Barrier," Choices, Vol. 4, 1986, pp. 18-21.

(3) Hathaway, D.E. "Trade Negotiations: They Won't Solve Agriculture's Problems," Choices, Vol. 4, 1986, pp. 14-17.

(4) Johnson, D.G. "Emphasis on Subsidies is Misplaced: The Basic Difficulty is High Prices," Choices, Vol. 4, 1986, pp. 26-27.

(5) McClatchy, D., and H. deGorter. "Reflections on the OECD Study Evaluating the Impacts of Agricultural Policies on Trade," unpublished mineograph, International Trade Policy Division, Agriculture Canada. Presented at the meeting of International Agricultural Trade Research Consortium, Wye Woods, MD, July 1984.

TRADE LIBERALIZATION: THE RESULTS FROM WORLD TRADE MODELS

Vernon O. Roningen[1]

Most countries intervene in their agricultural sectors in complex ways. Some of the intervention is with border policies such as taxes and tariffs but many countries, especially the developed ones, have a variety of complex "domestic" policies which guide their agricultural sectors and most importantly, have large spillover effects on world markets and world agricultural trade.

Past trade negotiations have largely dealt with trade-distorting measures at the border and the General Agreement on Tariffs and Trade (GATT), which hosts trade negotiations, has historically concentrated on trade-distorting border measures in the negotiating process. However, the upcoming round of trade negotiations is supposed to include agriculture and must of necessity deal with the analysis and negotiation of these complex "domestic" policy measures.

A very significant analytical and political beginning was made on the "agricultural" trade-negotiating problem in the Organization for Economic Cooperation and Development (OECD) in Paris. An analytical methodology was applied which allowed a simple summarization of all policies influencing agricultural supply and demand in terms of "producer" and "consumer" subsidy equivalents. These measures were inserted into a static modeling framework which allowed the calculation of the impacts of changing these policies. Concurrent with the OECD efforts, the World Bank commissioned a study for its 1986 development report which outlined the impact of the removal of agricultural protection on a worldwide basis (4)[2]. This World Bank model was developed by Australian researchers R. Tyers and K. Anderson. The model had less commodity detail than the OECD model but more coverage for developing countries.

These two models and their resulting analysis have provided an early basis for examining the potential impact of the removal of policies that distort world agricultural markets. They have served the same purpose (for agriculture) as earlier world models by Cline at the Brookings Institution, Baldwin at Wisconsin, and Stern at Michigan did prior to the last round of trade negotiations in outlining possible losses and gains from various liberalization scenarios.

At ERS, USDA, we have the responsibility for doing the same kind of model-based analysis to support U.S. participation in the upcoming trade negotiations, which will include agriculture. We have developed a model-building algorithm called SWOPSIM--a Static World Policy Simulation framework (2). The SWOPSIM framework was tested by using OECD and World Bank data and parameters to build our own versions of these models (named appropriately, OECD and BANK) using our SWOPSIM model structure. We then ran OECD and BANK liberalization scenarios and obtained essentially the same results as the OECD and World Bank did with their models. We have gained some experience from our use of our versions of the World Bank and OECD models and are applying it to our model-building efforts.

For example, the results of the OECD model simulations differ from those of the BANK model because of the assumed response for centrally planned countries and developing countries. The OECD model assumes no supply-demand response in the centrally planned countries to world price changes caused by liberalization of agricultural policies. The BANK model has

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[2]Underscored numbers refer to sources listed in the References at the end of this paper.

considerable country detail for developing countries and assumes fairly high long-term supply and demand elasticities for centrally planned and developing countries. As a test of this difference in responsiveness, we shocked the U.S. supply in our versions of the OECD and World Bank models and calculated the implied export demand elasticity for U.S. wheat. Our OECD model gives an implied U.S. wheat export demand elasticity of -2.7 (identical to the one calculated at the OECD with their model), while our version of the World Bank model implies an elasticity of -18. If, in turn, the price responsiveness of our BANK model for the centrally planned countries is turned off during a simulation (we have this capability in SWOPSIM), the implied elasticity for U.S wheat export demand falls to -4.8.

The above exercise of replicating and analyzing the OECD and World Bank models provided us with a validation of our modeling framework and highlighted some key sensitivity issues regarding the responsiveness of the nonliberalizing world to agricultural liberalization. We have now created a fairly large data base with associated protection measures (3). From this base and using the SWOPSIM algorithm, we have created appropriately sized world trade models to analyze trade liberalization issues for the United States. Our main trade liberalization model is called TLIB. (Currently in TLIB we have an implied elasticity of demand for U.S. wheat exports of about -6 without damping the responsiveness of the centrally planned countries.) Our SWOPSIM framework also has allowed us to create a Canada-U.S. free trade area model (CUFTAM), which incorporates an Armington-type demand system to handle the the bilateral trade flow issues that a free trade area analysis requires (1).

In summary, although the analytical problems of dealing with complex agricultural issues in trade negotiations are difficult, analytical methods have been developed and exercised, which allow us to deal with such questions. Our work will build upon the efforts at the OECD and the World Bank. Most importantly, our modeling framework allows extensive sensitivity analysis of agricultural trade liberalization results to parameters that have weak empirical bases.

References

(1) Dixit, Praveen M., and Vernon Oley Roningen. Modeling Bilateral Trade Flows with the Static World Policy Simulation (SWOPSIM) Modeling Framework. ERS Staff Report No. AGES861124, U.S. Dept. Agr., Econ. Res. Serv., Dec. 1986.

(2) Roningen, Vernon Oley. A Static World Policy Simulation (SWOPSIM) Modeling Framework. ERS Staff Report No. AGES860625, U.S. Dept. Agr., Econ. Res. Serv., July 1986.

(3) U.S. Department of Agriculture, Economic Research Service. Government Intervention in Agriculture: Measurement, Evaluation, and Implications for Trade Negotiations. FAER-229. Mar. 1987

(4) World Bank. World Development Report. Washington, DC, 1986.

BUILDING A WORLD TRADE MODEL: SOME LESSONS WE ARE LEARNING

Jerry Sharples[1]

The Agricultural and Trade Policy Branch (ATP) of the Agriculture and Trade Analysis Division, ERS, has been in the trade-modeling business for many years, working with large dynamic multicommodity models like GOL and the IIASA model, and small single-commodity models. We are currently building another world trade model as a part of a broader ERS study of trade liberalization. During our past and present modeling activities, we have learned some lessons. This morning, I will discuss some of those lessons as well as some present model-related problems.

The Optimal Trade Model

In our trade modeling work, we are constantly reminded of a concept called the "optimal trade model." One could think of this concept as a math ematical function:

Trade model = f (S, I, C, D, O)

with the arguments in the function being:

S = the problem setting
I = inputs to the modeling process (people and budget)
C = computer technology
D = data (prices, quantities, elasticities, etc.), and
O = other factors (omitted from this discussion).

The modeler wishes to maximize this function (that is, find the optimal trade model), given the current values of the independent variables. I'll discuss how the first four arguments of this function are shaping our current trade-modeling efforts.

The Problem Setting

The setting relates to the nature of the research problem and the nature of the research institution. Both have an impact on what constitutes an optimal trade model. As a part of its current trade liberalization study, ERS needs a world trade model for evaluating changes in various countries' agricultural policies--domestic policies and trade policies. This research problem dictates that the model should include such characteristics as multiple countries, multiple commodities, production, domestic consumption, trade, policies, etc.

Any model of significant size in ERS should be designed to have a useful life well beyond the immediate research needs. An agricultural trade model is no exception. We anticipate recurring trade policy and related issues that could be addressed with a trade model. To help ensure that a model will continue to be used in the institutional setting of ERS two additional model characteristics are desirable: quick turn-around and transferability. Quick turn-around is needed because of the short fuse on many requests for research that come from outside the agency. The model must be easy to modify, quick to solve, and give results that are easy to interpret, or else it will have very limited use in ERS. The model must also be relatively easy to transfer among researchers so that it will not die if one or two key researchers leave the project. The conceptually simpler, well-documented model has a better chance of surviving and being transferred among researchers.

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Inputs to the Modeling Process

The optimal trade model is also influenced by the available research budget and professional staff. A larger modeling effort can be pursued with more inputs. The equivalent of about 3 scientist-years (spread over about eight people) are being invested directly in model construction and use. Many more ERS researchers with country/region expertise are indirectly involved in constructing policy variables and evaluating model parameters.

Computer Technology

The trade model is being designed for the personal computer. The personal computer has provided a major breakthrough for policy modelers in ERS. It enables the analyst to obtain quick turn-around from sophisticated models at low cost. And the software allows excellent interaction between the model and the modeler. These characteristics greatly increase the potential for using formal models for policy analysis.

Data

The quality of the available data and coefficients help determine the nature of a model. The model is no better than the data in it. If the quality of the available data is poor, then there is little justification for building a complicated model. A trade policy model needs data for quantities (supplied, demanded, traded), prices, technical coefficients, elasticities, and policy variables for major traded commodities and countries. The quality of the data on quantities is relatively good, but the quality of the rest is quite poor. This suggests that a trade model should be kept relatively simple.

Given the current status of S, I, C, and D in the ATP Branch, we have defined what we think is an optimal trade model. To be more accurate, a modeling process is being followed that will yield one rather large trade model as well as many smaller trade models. It differs from past trade modeling activities in ERS because (a) we have learned from the past, and (b) there have been significant changes in several of the arguments in the trade model function, especially the introduction of the microcomputer.

I'll discuss two components of our current trade model: the structure of the model and the algorithm used to solve the model. We call the model "TLIB" for trade liberalization and we call the algorithm "SWOPSIM" for Static World Policy Simulation.

Structure of the Tlib Model

TLIB is a static, equilibrium, net trade, synthetic model of world agricultural trade in 1984. The complete model contains 22 commodities and 36 countries. As described below, world models with fewer commodities and countries can be constructed from the complete model.

We assume that the base year (1984) is in intermediate-run (3- to 5-year) static equilibrium. In other words, the model is designed so that the "base solution" reproduces the base year prices and quantities produced, consumed, and traded. Thus, this base solution represents the outcome as a result of agricultural policies that were in place in all countries in 1984. All of the model's price elasticities also represent a 3- to 5-year adjustment period.

One does policy analysis by changing selected policy variables in the base model and obtaining a new solution. The difference between the new and base static equilibrium solutions suggests how the policy change would have affected the world, as it existed in 1984, but after a 3- to 5-year period of adjustment.

TLIB is a synthetic model, meaning that the builders obtained the estimates of parameters from secondary sources rather than by using econometric techniques. The theory of competitive production, consumption, and trade of homogeneous goods is used to specify relationships among the parameters, and to reduce the number of estimates needed.

Why static? A static model is simpler than a dynamic model. The additional work of adding dynamics to the model does not appear to be cost effective at this time.

Why build a net trade model rather than a model that incorporates specific trade flows among trading countries, such as an Armington model or transportation model? The main reason is that the net trade model is simpler and requires less data. Besides, the main research interest of the trade liberalization study is not on individual trade flows among countries. We are, however, experimenting with an Armington version.[2]

The TLIB model is conceptually quite simple, yet it provides powerful conclusions. It provides estimates of net changes in production, consumption, prices, and shifts in welfare across sectors and countries for a wide variety of policy changes or other shocks to the base model. These changes, however, have to be interpreted within the context of the model's assumptions about how the world works. More is said in the last section about how one tests the validity of this model in representing the real world.

The Algorithm - SWOPSIM

The algorithm used to build and compute solutions to the TLIB model is called SWOPSIM.[3] Its creator is Vernon Roningen. SWOPSIM uses the latest spreadsheet software and can be handled by the more powerful microcomputers. The spreadsheet approach meets several of our objectives quite well. Its a widely used and flexible technology that simplifies the problem of transferring the model to other users. It allows interaction between the user and the model. And with the right match of model size and computer capability, the spreadsheet provides quick turn-around.

SWOPSIM stores data, builds trade models, solves trade models, and reports results. At present, the data set represents 22 commodities for 36 regions. The "model" discussed here refers to that total data set. From that common data set, however, SWOPSIM can create single-commodity world trade models or multicommodity models. It can create two-region world models or N-region world models with one region always being "the rest of the world." That flexibility allows the model to be tailored to the specific problem being investigated.

Modeling Problems

There are numerous problems associated with building a trade model. I'll mention five major problems that we had to address.

1. Base Period. The TLIB model is assumed to be in an intermediate run equilibrium in the base period. Thus it is important that world agriculture roughly approximate an intermediate run equilibrium during the base period. The base period might be defined as the average of

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[2] Praveen M. Dixit and Vernon Oley Roningen. Modeling Bilateral Trade Flows with the Static World Policy Simulation (SWOPSIM) Modeling Framework. ERS Staff Report No. AGES861124., Econ. Res. Serv., U.S. Dept. Agr., Dec. 1986.

[3] Vernon Oley Roningen. A Static World Policy Simulation (SWOPSIM) Modeling Framework. ERS Staff Report No. AGES860625., Econ. Res. Serv., U.S. Dept. Agr., July 1986.

several years or as one year. An average smooths out year-to-year random variations in prices and quantities. On the other hand, it is easier to define policies for a specific year. We chose to define a 1-year (1984) base period.

2. Time Horizon. Should the model be short run, long run, or something between? Since "trade liberalization" is the research issue, we discarded the short run and assumed that the model represented an equilibrium solution that would result after a 3- to 5-year period of adjustment.

3. Obtaining Price Elasticities. The full TLIB model needs about 3,600 own- and cross-price elasticities. It is impossible to obtain a consistent set of econometrically estimated values for all. In addition, the data do not exist for many countries. As a substitute, results of other studies are used and experts are polled. Further, theory provides opportunities to make simplifying assumptions. For example, first order conditions from a system of competitive supply equations can be used to specify certain cross-price elasticities.

4. How Insert Policy? There are three ways to insert policy into the TLIB model: (a) with price wedges between the world price and domestic producer and consumer prices (for example, producer and consumer subsidy equivalents), (b) by altering domestic supply and demand equations, and (c) with price transmission elasticities. We plan to use all three. We assume that when a country fully liberalizes trade, changes in world prices are fully transmitted to domestic producers and consumers. For these scenarios, price transmission elasticities are set at 1.0.

5. How Test the Model? How does one evaluate a static synthetic model? I know of no objective tests. By definition, the model will reproduce the base period. Alternative solutions are obtained by changing one or more parameters in the model. Those solutions represent outcomes that are not experienced by the real world in the base period. I conclude that an evaluation of the model must be based upon extensive sensitivity analysis and the analyst's judgment on the reasonableness of the results.

We use several sensitivity tests. For example, we estimate the implied elasticity of demand for U.S. exports by shifting the U.S. supply functions. Results show new export prices and new export quantities that can be used, with base solution export prices and quantities, to calculate export demand elasticities. Those export demand elasticities are functions of quantities and elasticities in all other countries. Thus, their interaction can be captured in one summary statistic that has some meaning to the analyst.

The model-building process described in this paper is summed up in one sentence in the text by Pindyck and Rubinfeld, "Model building is very much an art, and part of that art is learning to trade off alternative criteria in different ways.[4]

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[4]Robert S. Pindyck and Daniel L. Rubinfeld. Econometric Models and Economic Forecasts. Second Edition, McGraw-Hill Book Co., New York, 1981, p. 367.

U.S.-CANADA FREE TRADE: WHAT ARE THE ISSUES?

Mary Ann Normile[1]

The current initiative aimed at producing a free-trade agreement between the United States and Canada is the most recent in a series of similar efforts over history. The impetus for the current talks came from the newly elected Progressive Conservative government of Canadian Prime Minister Mulroney, and gained momentum at the March 1985 Montreal "Shamrock Summit" between Mulroney and President Reagan. The negotiations are currently proceeding under "fast track" authority in the United States, which imposes a January 1988 deadline for concluding an agreement, and stipulates that the U.S. Congress must approve or disapprove, but may not amend, the agreement. Teams of negotiators have met several times and have set up working groups on specific areas such as technical barriers (including phytosanitary restrictions) and subsidies.

The expected outcome of these talks is an agreement that results in free trade, or, what politicians now refer to as "freer trade," between the two countries. Such an agreement would reduce or eliminate trade barriers between the two participating countries, while maintaining existing barriers with third countries. An agreement aimed at establishing a customs union, common market, or economic/monetary union, which would imply a greater degree of economic integration, is not being considered.

Canada's principal objective in initiating the process aimed at obtaining a comprehensive free trade agreement is to obtain secure access to the U.S. market, which accounts for between 70 and 80 percent of Canada's exports. Many Canadian officials believe that secure access can best be achieved by obtaining relief for Canadian exporters from the increasing number of protectionist measures being applied by special interests under U.S. trade remedy laws (countervail, antidump, and safeguard). These officials see a bilateral agreement as a potentially effective way of restraining U.S. protectionist interests. A secondary Canadian objective is to use a bilateral trade agreement as a means of imposing better discipline on domestic industries in order to make them more competitive.

The probability of Canada's achieving its objective in the bilateral talks is low because it is negotiating from a weak bargaining position. The probability of success is low because of strong protectionist sentiment in the U.S. Congress, which is directly related to the strength of the U.S. dollar and the burgeoning trade deficit. There are high political stakes to achieving a bilateral trade agreement with the United States, and the importance placed on achieving a bilateral trade agreement by Canadian politicians has put added pressure on Canadian negotiators, weakening their bargaining position. Relative trade dependence is unbalanced; Canada is far more dependent on the United States for trade than the United States is dependent on Canada and, therefore, has more to gain (or lose) in a bilateral agreement. An added problem for the Canadian Government is that it not only has to negotiate with the U.S. Government but also with special interest groups and provincial governments at home. Consequently, the United States is more likely to be able to impose discipline on Canada than vice-versa. As a result, the outcome of negotiations will probably be much less ambitious, and less favorable to Canada, than was originally intended.

Canada's strategy was flawed from the outset. The policy of coalition-building and lobbying pursued in the early eighties was more promising of success than the free-trade negotiations are likely to be. The wisdom of the earlier strategy was demonstrated by the Canadian successes in opposing countervailing duties in the Bombardier subway car case and in the original softwood lumber decision. Canada could improve its bargaining position by building

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consensus at home, by building coalitions with groups outside Canada (such as U.S. consumers likely to benefit from tariff reductions), and by lobbying to alter rules of the game so they are less in favor of U.S. protectionists. Canada could also attempt to impose discipline on U.S. protectionists in the GATT by forming coalitions with other adversely affected countries. For these reasons, a bilateral trade agreement is not likely to be Canada's best strategy for fighting U.S. protectionism.

U.S. objectives in the negotiations are less clear. The United States is responding to the Canadian initiative and, as such, may not have had the advantage of preparatory study and analysis that the Canadians had. However, some general motives of the United States in pursuing a freer trade with Canada can be inferred. First, the U.S. competitive position in agricultural trade with Canada is worsening. The overall U.S. trade deficit with Canada is second only to its trade deficit with Japan; in agricultural trade, the United States became a net importer of agricultural products from Canada in 1985, reversing a long history of agricultural trade surpluses. Second, the United States would like improved market access for its agricultural products in Canada. U.S. producers of wheat and live hogs, for example, see as unfair a trading situation that permits Canadian products to move freely into the United States, while U.S. products are denied similar access to the Canadian market. There are also compelling political reasons for the United States to seek closer economic ties with Canada, who is not only the U.S. largest trading partner, but also an important ally. Lastly, the United States may want to achieve successful negotiation of reductions of protection and assistance to agriculture bilaterally as a demonstration of what can be achieved in trade liberalization talks to serve as "inspiration" for the multilateral trade negotiations (MTN).

In this connection, there are several parallels between the bilateral trade talks and the MTN. Approximately 75 percent of U.S.-Canada trade is duty-free; therefore, substantive work will have to be done in the area of nontariff barriers. There is a widespread perception that the GATT has failed as a means of settling trade disputes, and current settlement procedures for settling bilateral trade disputes are considered inadequate as well. A bilateral agreement will have to include a mechanism for adjudicating trade disputes that could serve as a model for improved dispute settlement procedures in GATT. However, bilateral talks offer an opportunity to go beyond what either country may reasonably expect to achieve in the MTN.

A CANADIAN AGRICULTURAL ECONOMIST'S PERSPECTIVE ON THE CANADA-U.S. TRADE LIBERALIZATION TALKS

John Spriggs[1]

The purpose of this discussion paper is threefold. First, I will describe the background to Canada's initiative in opening the trade liberalization talks with the United States. Second, I will present my assessment of the initiative. I argue that the initiative is unlikely to achieve Canada's primary objective (to restrain U.S. protectionsim) but may result in other benefits. Third, I will discuss an alternative trade strategy for Canada that I argue will be more successful in achieving the primary objective.

Background

The latest initiative on trade liberalization has come from Canada because of its high vulnerability in the international market. Canada does not have a large domestic market for its production and so must rely heavily on exports. Exports account for nearly 30 percent of Canadian gross national product (GNP), compared with only about 10 percent of U.S. GNP. Canada is particularly concerned with access to the U.S. market because that market accounts for between 20 and 80 percent of the value of Canada's exports. With the heavy trade deficit in the United States and the strong U.S. dollar, there has been a dramatic rise in protectionist sentiment in the United States which has posed a serious threat to Canadian access to this market.

The initiative can be traced back to the early eighties and the previous (Liberal) government in Canada. However, it was not until the present (Progressive Conservative) government that the initiative became a focus of Canadian Government policy. A number of Canadian industries were being threatened by protectionist lobbies in the United States (hogs, softwood lumber, paper, and fish). In addition, the government received a strong nudge toward trade liberalization by a 1985 report of a Royal Commission on the Canadian economy (the MacDonald report). The report urged Canada to take a "leap of faith" and open freer trade negotiations with the United States. The benefits of freer trade were seen as: (a) protecting Canada's access to the huge U.S. market, (b) encouraging Canadian industry to become more efficient, and (c) discouraging Canadian firms from relocating in the United States (to gain access to that market without worrying about trade barriers). The government took the "leap of faith" in early 1985 and made overtures to the United States administration about trade liberalization. At a summit between the leaders of the United States and Canada in March 1985, the President and Prime Minister agreed to examine ways to reduce or eliminate trade barriers between the two countries.

Since then, Canada has invested considerable resources in preparing for the negotiations. In addition, there has been wide and prolonged debate in the Canadian media on the pros and cons of a trade liberalization agreement (TLA). By contrast, on the U.S. side, there has been little interest in the trade liberalization talks. Nonetheless, the talks on a comprehensive TLA are continuing with the following items, the main ones being discussed:

(1) the elimination of technical barriers to trade (for example, health regulations);

(2) the elimination of trade-distorting subsidies;

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(3) elimination of tariffs;

(4) exemption from or modification to contingency protection laws (countervail and antidump);

(5) greater access to government procurement contracts;

(6) freer access to services markets; and

(7) transitional policies (that is, assistance to industries that are forced to adjust).

Canada is particularly interested in (4) and (7), while the United States is more interested in (5) and (6).

Assessment of the Initiative

Canada's primary objective in pursuing this initiative was to gain relief for Canadian exporters from the increasing protectionist pressure being applied by U.S. special interests under U.S. trade remedy laws (countervail, antidump, and safeguard). The Canadian Government thus went into the negotiations thinkings that a TLA would be an effective way to restrain (discipline) U.S. protectionists. However, what the government and the rest of the country are beginning to realize is that the country with the biggest stick carries out most of the discipline. The main reasons why Canada appears to be in a poor bargaining position are as follows.

(1) Protectionism is very strong in the United States at present. This is reflected in the attribute of Congress which has over the years gained ever-greater power over the determination of trade policy from the Administration. The trend to greater U.S. protectionism is linked to the strong U.S. dollar and burgeoning trade deficit. It may also be linked to the increasing awareness of and skill in using the U.S. trade remedy laws.

(2) The Canadian Government adopted a high profile in its search for a TLA with the United States. The achievement of a TLA was made a cornerstone of the government's economic platform. This placed considerable added pressure on the Canadian negotiators to reach an agreement, and hence weakened their bargaining position. To his credit, the Prime Minister appears to have been backing away from this position in recent months. Hence, this may be less of a factor now.

(3) Canada is relatively far more dependent on the United States for trade than the United States is dependent on Canada.

If a comprehensive TLA were negotiated, the outcome would reflect a situation in which the United States disciplines Canada with respect to its subsidies and distortions but there is little scope for Canada disciplining the Unites States with respect to its subsidies and distortions. Hence, a comprehensive TLA will not be very successful in achieving the primary objective of the Canadian Government.

A possible secondary objective is more likely to be realized by a TLA. This objective is to encourage Canadian business to be more internationally competitive, which would be good for Canadian consumers and taxpayers. Since we have already argued that the main effect of a TLA is that the United States would be better able to discipline Canadian business with respect to subsidies and distortions, it follows that Canadian business would be subjected more directly to the principle of "survival of the fittest." Even without such an agreement, the rising tide of U.S. protectionism and the application of U.S. trade remedy laws are encouraging a rethinking in Canada of the use of subsidies in export-oriented industries. The advantage of a comprehensive TLA is that it will encourage this kind of rethinking in a

broader set of Canadian industries than just the export-oriented ones. For example, some rethinking might be expected in those domestically oriented industries that would face potential competition from the United States under a TLA.

One major spinoff benefit of the TLA negotiation process is that it has been a valuable exercise leading up to Canada's participation in GATT. There has been an unusually wide-ranging debate over trade issues that should prove very useful to developing Canada's position at GATT. This debate has included input from all sectors of Canadian society: from various industry groups, labor groups, and the provinces, as well as many other special interest groups. In addition, many staffers assigned to work on the bilateral trade initiatve are also working on the GATT negotiations and they should benefit from the overlap between the two.

Thus, there appear to be some gains from a comprehensive TLA even if they come more from a secondary objective and a spinoff benefit rather than from the primary objective. However, despite these potential gains, the probability of success appears to be low.

Most experts agree that it is very doubtful that a comprehensive TLA will be achieved with the present Republican administration. And if the next administration is led by a Democrat, it has been suggested that the negotiations will be even more difficult for Canada (because Democrats are thought to be more protectionist). The reason for doubt is the inherent complexity of such an agreement as well as the very tight timetable for reaching agreement during the present U.S. administration. The complexity arises in Canada because it would involve tradeoffs in which some industries and regions or provinces would gain, while others would lose. The problem for the Canadian Government is that it not only has to negotiate with the U.S. Government but also with special interest groups and provincial governments within Canada. For example, many agricultural marketing boards and subsidy programs are subject to provincial or joint federal-provincial jurisdiction.

The deadline for achieving an agreement with the present administration is October 1987. This is necessary in order to gain approval from Congress under the "fast track" mechanism which expires January 3, 1988. Failure to achieve this deadline would almost certainly mean failure to achieve acceptance under the current presidency. Added to the time difficulties may be the recent change in structure of the Senate Finance Committee and Congress in general to domination by the Democrats.

While the negotiators in Ottawa are still focusing their attention on the idea of a comprehensive agreement, there is now some talk of a 'fall-back' position if and when the comprehensive agreement fails to materialize. A fall-back position may include an attempt to get some bilateral commission to address trade irritants (for example, technical barriers such as health regulations and customs inspection procedures). A paper by Bruce and Kerr (discussed in the next session) outlines a proposal for such a commission for livestock and livestock products. I suspect that such a commission would not be too difficult to negotiate in the limited time available. However, it seems unlikely that it would be given any real power by either side to settle trade disputes. Its role would likely be limited to providing an extra channel of communication between the two sides. This may be useful as a safety valve and as a way of allowing the two sides to settle disputes and irritants rather than going through the countervail process.

An Alernative Trade Strategy?

I have argued that this initiative is useful in encouraging Canadian business to be more internationally competitive, but it will not be very successful in restraining U.S. protectionism. The question is: is there another strategy that would have a greater chance of success in

achieving this objective? In broad terms, I think Canada's strategy needs to concentrate on building up its bargaining power vis-a-vis the United States. This may be done through:

(1) building a consensus within Canada (between the federal and provincial governments, labor and industry) so that Canada speaks with a unified voice;

(2) building coalitions with groups outside Canada (in the United States and elsewhere) who are expected also to be adversely affected by U.S. protectionism; and

(3) lobbying in the various forums of power to alter the rules of the game so they are less in favor of the U.S. protectionists. The most important forums of power are in the United States (the Congress, the Administration, State legislatures) and the most important groups with which to form coalitions are those inside the United States (processors, marketers, and consumers of the imported products, as well as taxpayers). However, there are forums of power outside the United States (GATT) and here Canada may attempt to impose disciplines on U.S. protectionists by forming coalitions with other adversely affected countries.

The idea that Canada should get involved in lobbying and coalition-building is not a new one. In fact, it was the strategy adopted by Canada in 1983 and which worked so well in the 1983 softwood lumber case. However, it seems to have been pushed aside by the thrust of the bilateral trade negotiations.

With respect to agricultural commodities (especially grains), I think Australia provides perhaps the clearest example of where this strategy is currently being embraced. Here the emphasis has been on reducing protectionism in the European Community (EC) and the United States. Last year, Australia's Bureau of Agricultural Economics (BAE) completed a well-publicized study of the agricultural policies of the EC. One factor that sets this study apart was the emphasis given by the BAE on publicizing the results inside the EC itself. This suggests that the study's main objective was to develop coalitions <u>within</u> the EC (consumers and the labor force) by pointing out the heavy cost to them of the common agricultural policy (CAP). It is interesting to note that the BAE recently embarked on a similar exercise looking at U.S. agricultural policies. And the emphasis is expected to be on the cost of these policies to groups <u>within the United States</u> (taxpayers). In another initiative, the Australian Government recently organized a ministerial meeting of "fair traders in agriculture." The participants were from 14 countries not including the United States, EC, or Japan. The Australians saw the main objective of the meeting to enable "an important group of countries to increase their collective negotiating leverage" at GATT. Australia was, in effect, attempting to build a coalition of agricultural exporting countries at the GATT forum to address the problem of agricultural protectionism in the United States, EC, and Japan.

With respect to the secondary objective the question is: does Canada need a TLA to achieve greater discipline of its domestic industry? Certainly the current U.S. trade remedy laws are having some effect, and pressures from other countries (through GATT) will have some effect. A strong Canadian Government could also play a part in imposing greater discipline on domestic industry. The problem of course is that unilateral actions to reduce protection are very unpopular and can expect strong resistance from the provinces and special interests. I would say that the advantage of a TLA over the current application of U.S. trade remedy laws is that the discipline imposed on Canadian business would be more broadly based and less capricious.

CHINA'S PAST AND FUTURE ROLE IN THE GRAIN TRADE

Colin Carter[1]

China's grain production, consumption, and trade are key factors in the world grain market. In the sixties, China emerged as a major wheat importer, and observers expect this situation to continue, mainly because China has 20 percent of the earth's population but only 7 percent of the earth's arable land. However, China's wheat imports dropped off sharply in the mideighties and there is much uncertainty surrounding China's future role in the grain trade.

The purpose of this seminar is to report on a paper that analyzes China's historical role in the world grain markets; studies the impact of the 1979 reforms on China's grain production, consumption, and trade; and evaluates the probable participation of China in the grain trade in future years. China is so large that regional differences in climate, level of government, and growth rates in grain production are substantial. Because of this regional heterogeneity, it is important to attempt to disaggregate analysis of China's grain economy whenever data allow. While data availability limit the regional detail desired, an effort is made to address these regional differences in the statistical analysis in this paper.

Using regional consumption and production models, a grain balance sheet (table 1) is constructed. The first scenario, with a high rate of increase in grain prices and a low production growth rate, suggests that China's grain production will be in surplus and the surplus will continue to increase in the nineties. However, this scenario is rather unlikely, given the government subsidy burden that would be involved and the low population growth rate that is used.

The third scenario with low grain prices and a high population growth rate projects serious shortages of grain in China. The projected shortfall is 44.6 million metric tons (mmt) in 1990, increasing to 75.7 mmt in 1995 and 118.3 mmt in 2000. Such drastic shortages, however, would lead undoubtedly to government preventive action. For example, when China's grain production declined by 6 percent in 1985 (from 1984 levels), due in part to slowed rates of increase in grain prices, the Government immediately announced a plan to permit farmers to sell more grain in the free markets and for them to obtain subsidies from village industries.

The second scenario, which is considered most probable, assumes medium increases in both grain prices and the population. It suggests China's grain supply will not be completely adequate. The grain shortfall is projected to increase from 20.2 mmt in 1990 to 26.1 mmt in 1995 and then to 36.0 mmt in 2000.

For many reasons, the Chinese Government would like to reach a level of self-sufficiency in grain. However, under current circumstances, grain self-sufficiency is not likely to be reached unless there is some major technological development. In this study, the most likely annual shortfall is projected at less than 30 mmt for most of the nineties. A large part of this deficit may be reduced with imports. Past experience indicates grain imports are not in conflict with the Government's policy toward grain self-sufficiency, for this level of imports is well within China's capability in terms of transportation and balance of payments.

The composition of imports may also change. Projections show that further increases in grain consumption will come mainly from an increased feed requirement of about 3 mmt per year, a rate which may exceed increases in coarse grain production. Since the share of wheat in total grain output is not expected to decline, future grain imports will most likely be in feed grains.

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[1]The author is an associate professor, Department of Agricultural Economics, University of California, Davis.

Table 1--Projected domestic grain balance sheet for China, 1990-2000

Item	Output	Consumption1/	Seed	Industrial uses	Changes in stocks	Deficit
			Million metric tons			
Scenario 1: 2/						
1990	467.1	433.7	16.9	4.2	3	-9.3
1995	534.0	485.8	16.0	5.2	3	-24.0
2000	595.3	543.3	15.1	6.2	3	-27.7
Scenario 2: 3/						
1990	440.7	436.9	16.5	4.2	3	20.2
1995	489.6	491.8	15.7	5.2	3	26.1
2000	540.7	552.8	14.7	6.2	3	36.0
Scenario 3: 4/						
1990	417.4	438.0	16.8	4.2	3	44.6
1995	443.6	495.5	15.5	5.2	3	75.7
2000	465.0	559.7	14.4	6.2	3	118.3

1/ The figures for total grain consumption are expressed in unprocessed form by applying an 82% milling rate to food grain, a 4.1 feed-to-meat ratio, and a 97.1 spirits-to-grain ratio and then summing them up.
2/ High rate of increase in grain purchasing prices and low growth rate for population. The assumed population growth rate is: 1.1% for 1985-90; 1.0% for 1991-95; and 0.9% for 1996-2000. The assumed price growth rates are: 6% for 1985-90; 5% for 1991-95; and 4% for 1995-2000.
3/ Medium growth rates for both population and grain prices. Population: 1.25% for 1985-1990; 1.1% for 1991-95; and 1.0 for 1996-2000. Prices: 5% for 1985 1985-90; 4.5% for 1991-95; and 4% for 1996-2000.
4/ Low rate of increase in grain purchasing prices and a high rate for population growth. Population: 1.3% for 1985-90; 1.2% for 1991-95; and 1.1% for 1996-2000. Prices: 4% for 1985-90; 3.5% for 1991-95; and 3% for 1996-2000.

Conclusions

China has played an important role in the world grain market in the past, but, given its recent economic reforms, its future participation is uncertain. This seminar reports on a study that evaluated China's historical role in the grain trade; analyzed the impact of economic and policy variables on grain production, consumption, and trade; and based on alternative policy scenarios, projected China's future levels of trade.

Imports in the early eighties were required because of increased rural grain resales to farmers who were adjusting to the policy changes. In the mideighties, stocks built up and there is no short-term pressure for increased imports. Chinese grain yields were quite responsive to price increases under the 1979 reforms. However, budgetary pressures will limit further increases in grain prices so that the growth in China's grain yields will slow. As the total population continues to increase, China's area sown in grain will decline. This is a serious problem in China.

The Chinese will gradually shift their food consumption toward more meat and other indirect grain consumption. Therefore, China may continue to import a limited amount of grain, but imports will shift from wheat to feed grains. China's grain production target under the seventh 5-year economic plan is 520 mmt and this does not appear to be overly optimistic.

MANDATORY SUPPLY CONTROLS AND TRADE

William Meyers[1]

The term "mandatory supply controls" refers to a program where farmers are obligated to control acreage in a manner specified by the government. Under current "voluntary acreage reductions," farmers are induced by economic incentives to take land out of production. In the United States, mandatory supply control proposals have always been coupled with a referendum in which a majority of farmers must accept the program before it is implemented. Therefore, mandatory supply control proposals inevitably require a higher price for producers than those under current programs, since a higher price is required in order to entice farmers to accept the proposal in a referendum.

A recent proposal of this type was Senate File 2869, proposed by Senator Harkin of Iowa. The proposal was to raise loan rates to 70 percent of parity in 1987 and increase the parity rate 1 percentage point annually to a maximum of 80 percent of parity. This proposal also carried a provision for subsidizing exports in order to prevent the inevitable loss of export markets when production is cut back to achieve these high domestic price levels.

Scope of the Analysis

Since the purpose of this brief paper is to generate discussion on the trade effects of mandatory supply programs, the analysis is limited to wheat and feed grains and is conducted under very simplified assumptions. This analysis cannot be interpreted as an evaluation of Senate File 2869, since it does not follow the complete provisions of that program. For comparison purposes, three alternatives scenarios are analyzed:

(1) Mandatory supply controls with high prices for a single commodity,
(2) mandatory supply controls with high prices for all competing crops, and
(3) mandatory supply controls with export subsidies to maintain the export levels under current programs.

The emphasis of the first two cases is to compare the export response to higher prices when only one price is increasing and when all crop prices are increasing together. The emphasis of the third case is to compare the costs of payments to farmers under current programs to the cost of payments on exports required to prevent export losses under the mandatory supply program. One argument for mandatory supply controls has always been that it is a way of saving government funds, while providing farmers with higher income. With the export subsidy provision, it is not clear whether the program would cost more or less than current programs.

The support prices assumed for all three cases are presented in table 1. These begin at 70 percent of parity for individual commodities in 1986/87. The prices increase across time both because the parity percentage rate is rising by 1 point per year and because the parity index is rising with the producer price index projections. The CARD/FAPRI regional trade models for feed grains, wheat, and soybeans were used for the analysis.

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[1]The author is professor of economics and associate administrator of the Center for Agricultural and Rural Development, Department of Economics, Iowa State University.

Table 1--Assumed U.S. support prices for mandatory supply programs

Commodity	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96
					Dollars per unit					
Corn (short ton/bu)	3.46	3.55	3.70	3.87	4.03	4.21	4.45	4.71	4.99	5.34
Wheat (short ton/bu)	4.74	4.86	5.08	5.30	5.52	5.77	6.10	6.45	6.84	7.32
Soybeans (short ton/bu)	8.54	8.76	9.15	9.56	9.94	10.41	11.00	11.62	12.32	13.11
Cotton (short ton/lb)	.87	.89	.93	.97	1.01	1.06	1.12	1.18	1.25	1.34
Rice (short ton/cwt)	13.51	13.86	14.47	15.12	15.73	16.46	17.40	18.39	19.50	20.86
Dairy (short ton/cwt)	16.31	16.74	17.47	18.25	18.98	19.87	21.00	22.20	23.54	25.19
Soymeal (short ton/st)	210.93	216.36	227.38	231.11	245.26	255.23	268.44	279.89	292.30	310.50

Mandatory Supply Controls With No Export Subsidy

When there are no export subsidies, the reduction in U.S. supplies and the increase in prices reduce world import demand, increase competitors' exports, and reduce U.S. exports. The final impact on U.S. exports is dependent upon the export demand elasticity. Since the price response in the regional trade models used for this analysis depends on the underlying supply and demand elasticities in the importing and exporting countries, the export response price depends both on which prices are changing and the duration of the price change. Previous analysis with these models indicates that the response for price change is greater when only one price is changing and increases with duration of the price change.[2]

Figure 1 illustrates the comparison between case 1 and case 2. The single-commodity effect, when only the own-commodity price is changing, is indicated by the point SC. In this case, exports decline from X_O to B and the required supply reduction is A-B, given the initial supply and demand curves. The cross-commodity result, when all prices are increasing together, is denoted by the point CC. In this case, the higher prices of other commodities shift the demand to the right and the supply to the left in U.S. and foreign markets, resulting in an export decline from X_O to D and an implied supply reduction of C-D.

The results of the analysis for wheat are presented in figures 2-5. The decline in wheat net imports is very similar in the two cases, since there is relatively little cross-price effect with other commodities among the wheat-importing countries (fig. 2). Competitor's wheat exports expand dramatically under the single-price case, but show relatively little change when other crop prices are increasing as well. This is a consequence of the strong cross-price effects with other grains in the major wheat exporting countries (fig. 3). U.S. wheat exports drop to zero by 1995 in the single-commodity case and remain near the low 1985 level under the cross-commodity case (fig. 4). In this case, the U.S. export share would continually fall throughout the period. The value of export results (fig. 5) indicate that the implied price response of U.S. exports is elastic when only wheat prices are changing, causing export values to decline, but are inelastic when all prices are changing, causing the value of wheat exports to rise.

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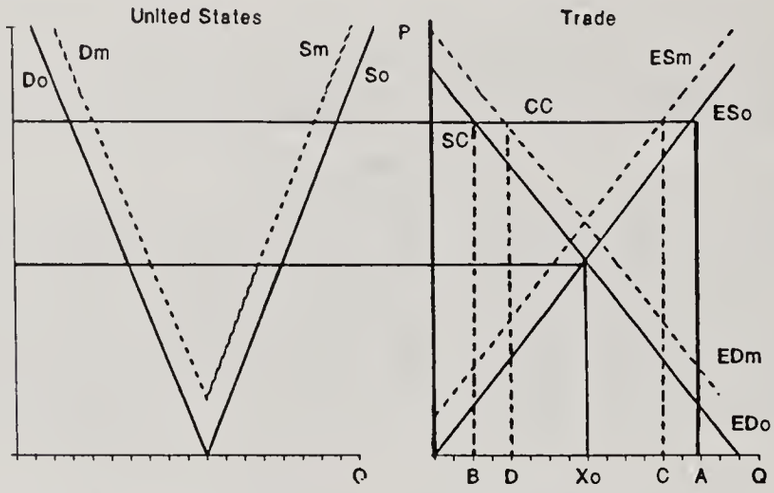
[2]Meyers, William H., S. Devadoss, and Michael Helmar. "The U.S. Export Response to Prices and the Impacts of Trade Liberalization: A Regional Trade Model Analysis." Working Paper No. 86-WP15. Center for Agricultural and Rural Development. Sept. 1986.

Figure 1

Mandatory supply controls with no export subsidy



where: o and m subscripts denote demand and supply with other prices constant, and with other prices at higher mandatory level, respectively.

Pm is the mandatory price.
Po is the initial price.
Xo is the initial export level.

Figure 2

Wheat net imports

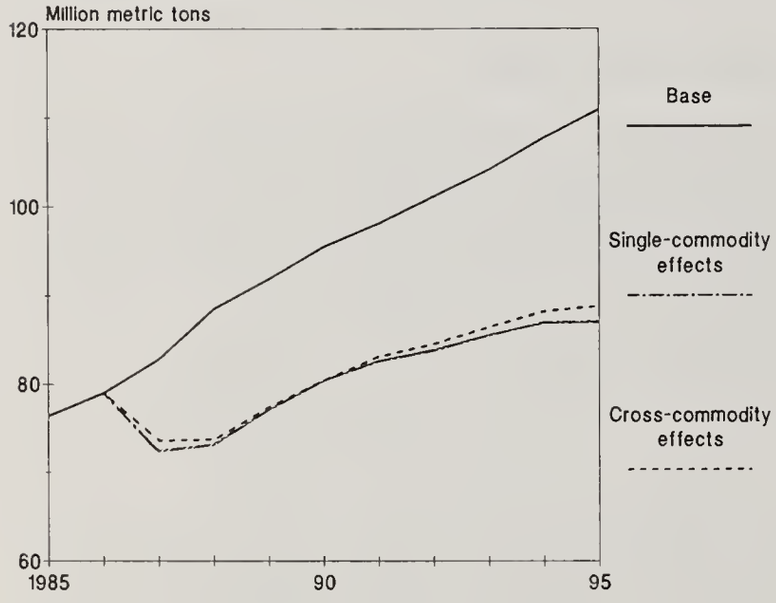


Figure 3

Competitor wheat exports

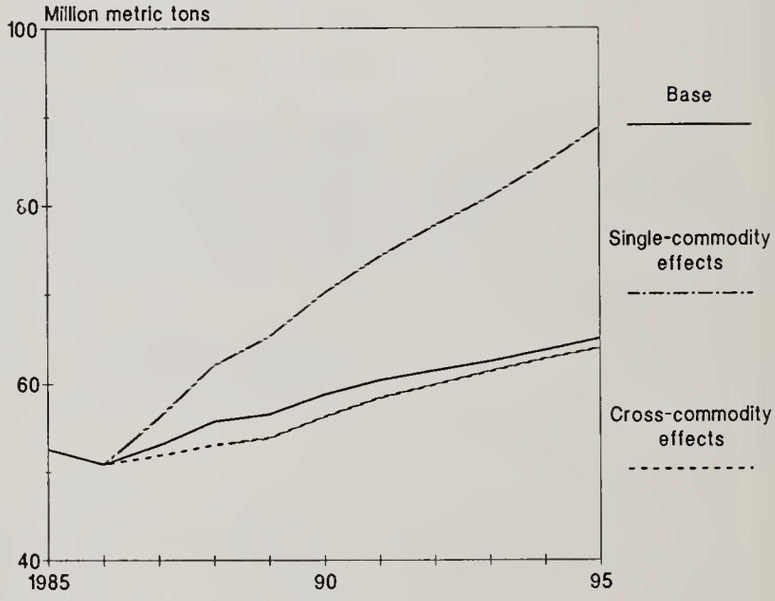


Figure 4

United States wheat exports

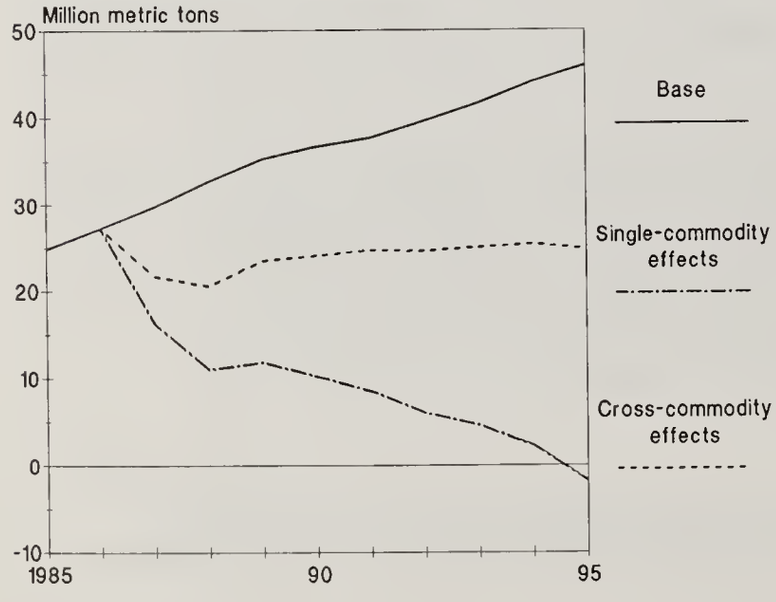
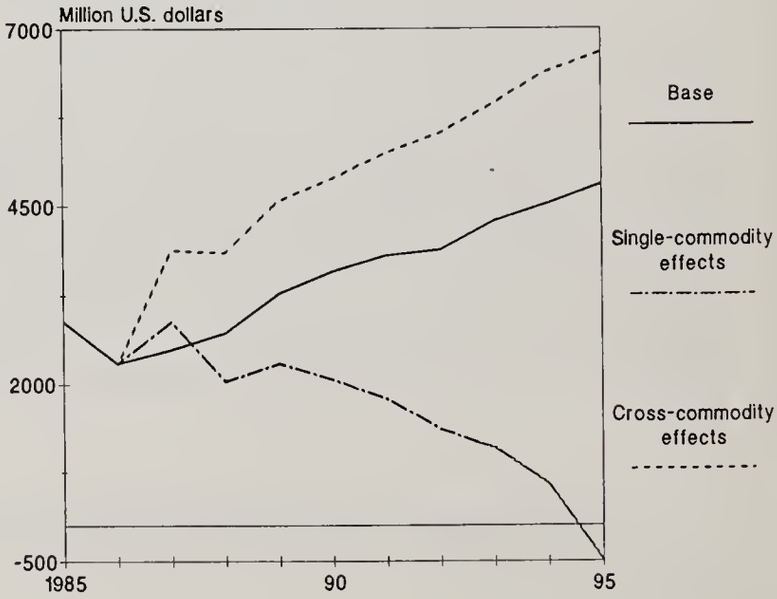


Figure 5

Value of wheat exports



The results for feed grains and corn are fairly similar (figs. 6-9). In the case of feed grains, competitors' exports increase in both cases, although the increase is smaller in the cross-commodity case. The United States has a greater share of world production and trade in feed grains, so exports do not fall as rapidly as wheat in the single-commodity case. The implied export elasticity in the single-commodity case is near 1; but, again, the implied elasticity in the cross-commodity case is inelastic.

Since these models are primarily based on empirical data over the past 20 years, it is likely that the estimated equations underestimate the response of supply to such large price changes as these. These is no historical experience of similar magnitudes of changes in prices, so the prices used in these analyses are outside the range of data used in estimating these supply and demand relationships.

Mandatory Supply Control With Export Subsidies

The provision for export subsidies is proposed to mitigate the criticism that this kind of policy would drastically reduce export levels and market share. This provision, of course, also adds another cost dimension, which will offset the savings generated by eliminating the target price-deficiency payments scheme. The analysis here is designed to compare these two costs under the assumption that the export levels in the baseline under current programs would be maintained.

This comparison is illustrated in figure 10. It is expected that the mandatory price level would be greater than current target prices. Thus, the payment per unit of export would be higher than the payment per unit made to the farmers under current programs. It is not immediately obvious whether the total cost would be higher or lower, since the quantity of exports X_O is less than the quantity of production on which deficiency payments are made. In figure 10, the supply S_O includes the acreage reduction required for participation in the target price program, and it is assumed that all producers are participating. Thus, when the higher price P_m is guaranteed to producers and export levels X_O are maintained, an additional acreage reduction of A-X is required to clear the market. The difference in the program costs is area G_m less area G_O.

The export subsidy costs are compared to the government costs for grains, soybeans, cotton, and dairy in figure 11. The cost of mandatory supply controls with export subsidies are lower until fiscal year 1992. Thereafter, the costs of the export subsidy program continue to rise, because the payment per unit is increasing at the same time as the rise of exports is increasing. By contrast, the cost of current programs is declining, so the gap between the two reaches more than $14 billion by fiscal year 1995.

Conclusions and Implications

This is obviously not a complete analysis, since it does not take into account the changes in farm income or the cost to domestic consumers of the higher prices in the domestic market. Looking just at the trade implications, it is clear that this approach to provide higher income to domestic producers would lead either to an isolated domestic oriented agriculture or to higher government outlays, which would continue to increase the longer the program was maintained.

Figure 6

Feedgrain net imports

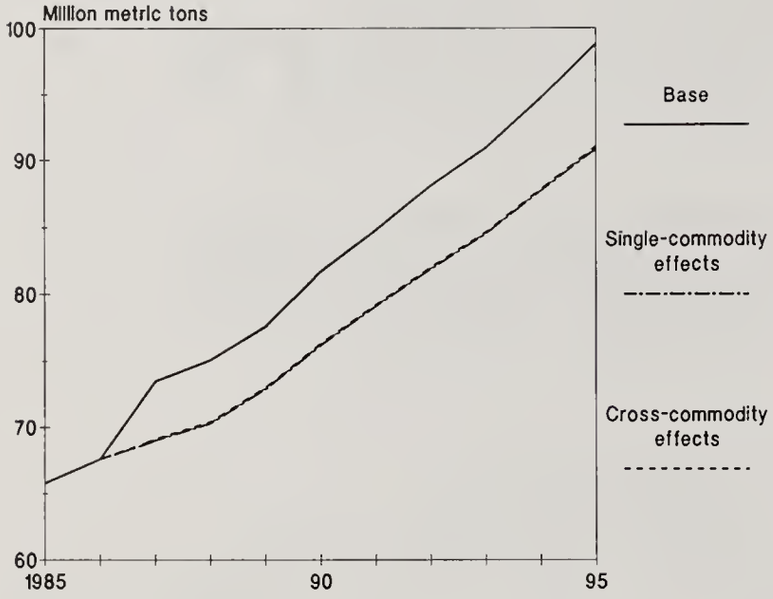


Figure 7

Competitor feedgrain exports

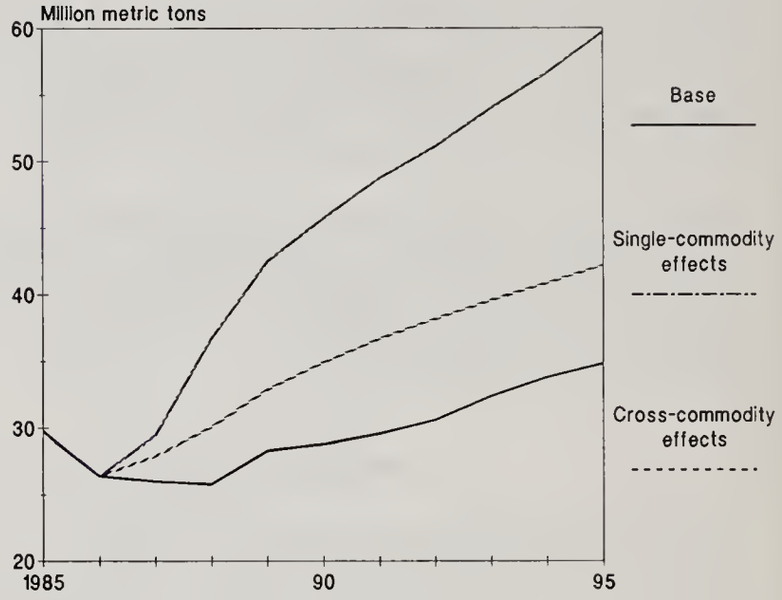


Figure 8

United States corn exports

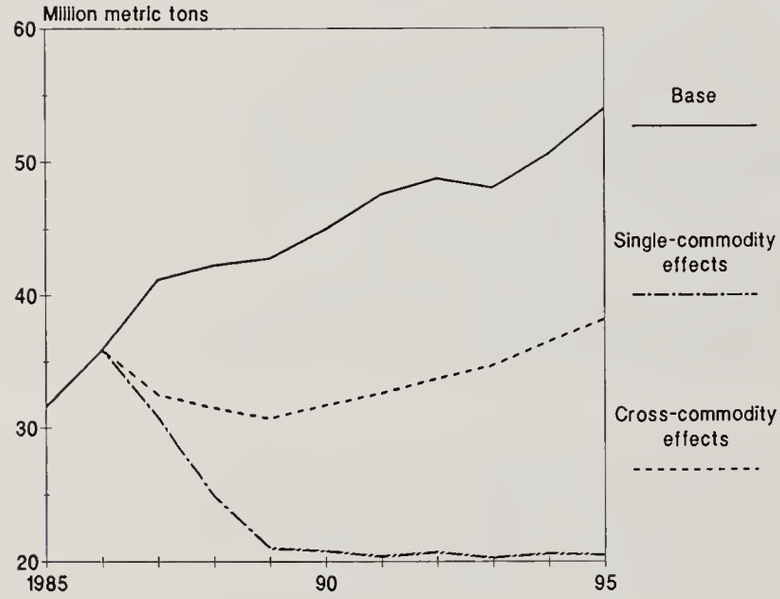


Figure 9

Value of United States corn exports

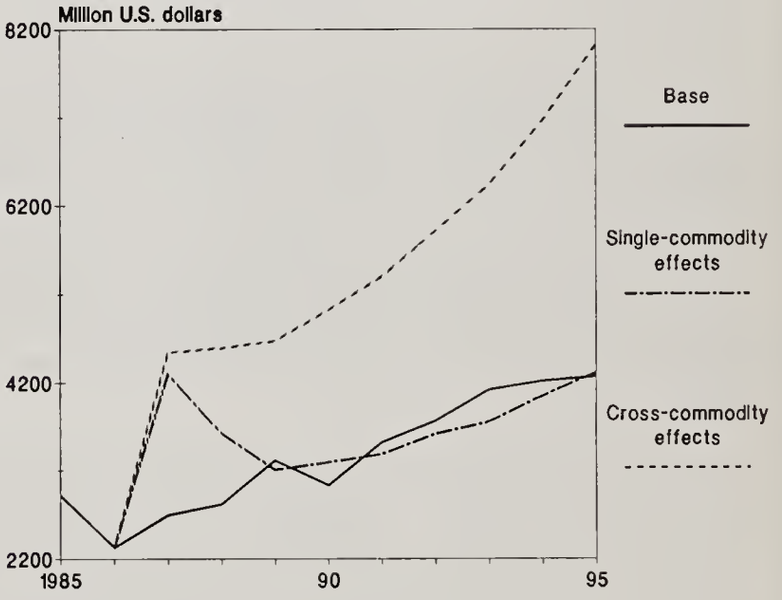
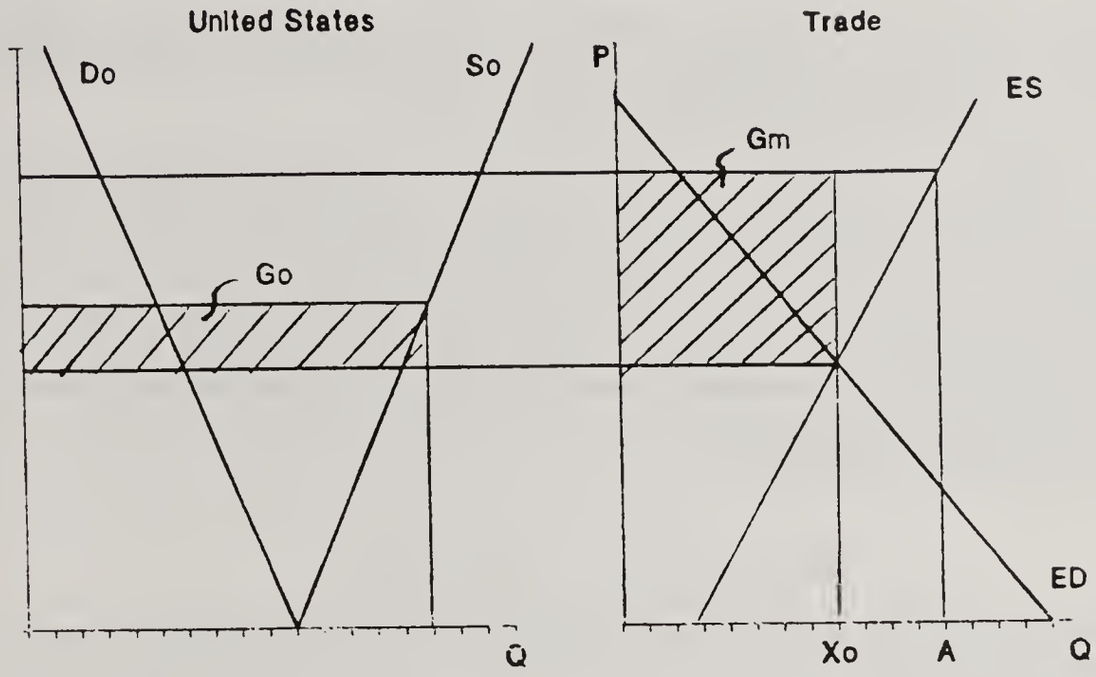


Figure 10

Mandatory supply controls with export subsidy versus current program

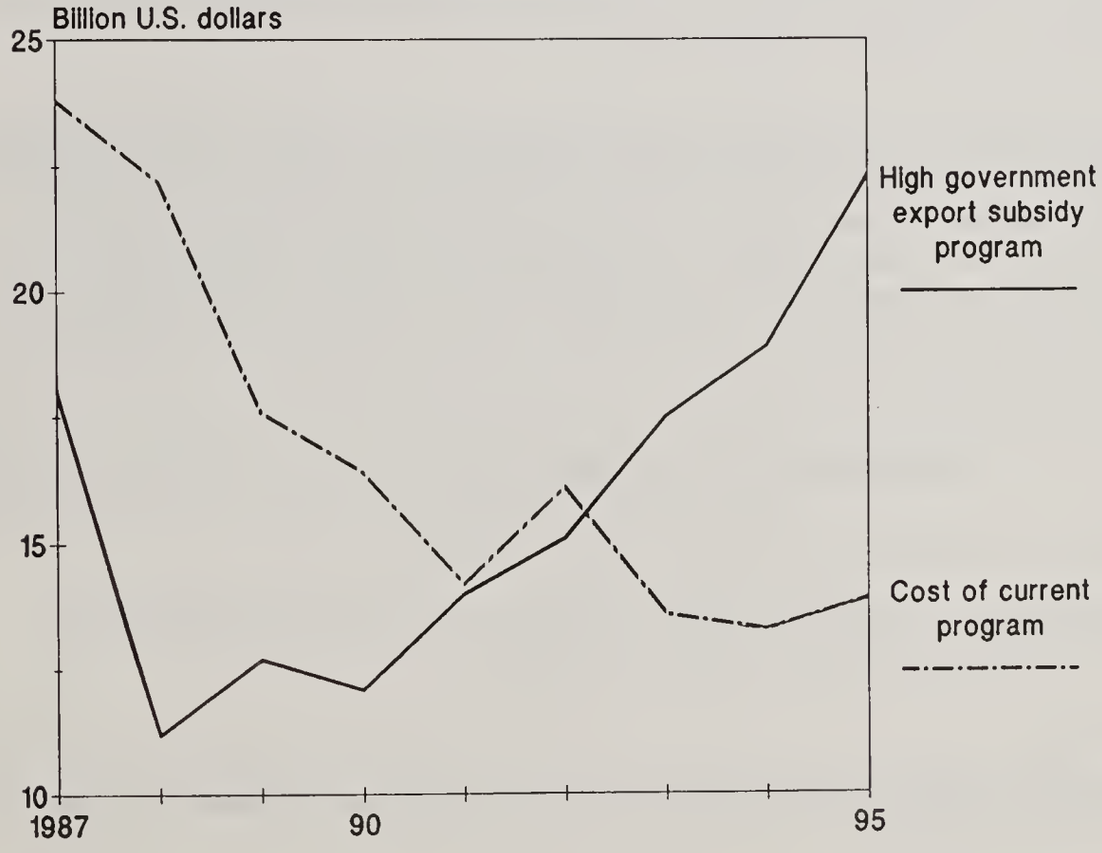


where: Gm is mandatory program cost.
Go is the current program cost.
Pm is the mandatory price.

Pt is the target price.
Po is the initial market price.
Xo is the initial export level.

Figure 11

Government cost comparison



TAX REFORM POLICIES IN DEVELOPING COUNTRIES

Cathy L. Jabara[1]

Tax reform and tax policies in developing countries have long been studied by economists. However, in the last few years, tax reform has gained increased recognition as an important policy instrument for stimulating developing country economies.

In particular, the adoption of growth-oriented macroeconomic and structural policies by the debtor nations is at the heart of the "Program for Sustained Growth" ("Baker Plan") proposed by the United States for the major debtor nations in Seoul, Korea, in October 1985. Under the program, debtor countries would adopt macroeconomic and structural policies that improve growth and reduce inflation in order to qualify for new loans from the International Monetary Fund (IMF), the World Bank, and private banks. Growth-oriented policy reforms include reducing subsidies and costly budget deficits, as well as structural reforms involving the development of efficient domestic capital and equity markets, increased efficiency in the public sector, and growth-oriented tax reform.

Institutional Views on Tax Reform

Among international development institutions, the IMF has had the most influence over tax policies in developing countries. Tax provisions are part of IMF packages, but not of explicit conditionality.

The IMF primarily views the tax system as an instrument of short-term "demand management" involving changes in private consumption and government revenue. Since the IMF aims at stabilization, its revenue concerns are primarily shortrun, and balance of payments and budget deficits are its top negotiating aims. Budget deficits often require a revenue increase. IMF tax measures usually favor quick-impact tax changes such as increases in sales taxes, import duties, user charges, and public enterprise tariffs. They recommend increases in income and corporate taxes only as a last resort.

However, in the context of growth-oriented tax strategies, the role of taxes in long-term "supply managment" and resources allocation also becomes important. This supply management perspective recognizes that the tax structure affects decisions by economic agents, and thus resource allocation, and that growth prospects could be improved with a tax structure that distorts these decisions less. This perspective also suggests close linkages between tax policy and the structural adjustment work of the World Bank. Both the development projects and structural adjustment supported by the bank take place within an environment conditioned in important ways to tax policy.

Characteristics of a Good Tax System

The criteria most widely accepted for a good tax system include:

> Economic neutrality. Tax systems should not interfere with efficient allocation of resources, nor result in bias against capital formation.

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[1]The author is an economist, U.S. Treasury Department. The views expressed in this paper are the author's and cannot be attributed to the U.S. Treasury.

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Horizontal equity. Structure tax laws so that those who are able to pay, pay more or less equally.

Simplicity. Aim for easy compliance.

Low rates. Low rates on a broad base bring more development and few bad economic decisions.

Inflation-proof the system. Taxes should adjust automatically high inflation.

Characteristics of Tax Systems in Developing Countries

Statistics on the composition of central government revenues for more than a 100 countries reveal that taxes on income and profits are more important in the industrial countries (33 percent of revenue) than in the developing countries (17 percent of revenue in the least developed countries).[2] The contribution of taxes on international trade and transactions is inversely related to the level of income and the degree of industrialization (42 percent of revenue in the least developed countries). The degree of reliance on domestic taxes on goods and services is greatest in the semi-industrial countries.

In many low-income countries, direct taxes on agricultural producers tend to be very light, since the sector, particularly if comprised of smallholders, is difficult to tax. Instead, taxes on agricultural producers are more commonly levied through price and trade taxation. For instance, the incomes of ejido farmers in Mexico are not taxed directly. Agricultural producers in India also do not pay income taxes on agricultural income. A number of countries provide income tax incentives to commercial agricultural development. For example, commercial income from animal husbandry and poultry farming is tax exempt in India, Pakistan, Bangladesh, and Sri Lanka. Both Brazil and Mexico apply lower, preferential corporate income tax rates to income earned from commercial agricultural enterprises.

Tax Reform Issues

In most developing countries, existing tax systems do not necessarily represent a neutral or equitable mechanism for raising revenue. Tax systems have often developed in piecemeal fashion with the purpose of protecting specific sectors or interest groups, or of raising more revenue. Thus, the tax structure many not fit together to achieve development goals. Tax rates are often high and imposed on a narrow base, which provides incentive for tax evasion. Complex systems prove too difficult for tax officials to administer.

A survey of recent tax reforms undertaken by five developing countries presents evidence that, in most cases, the reforms represent attempts by countries to reduce the negative effects of tax systems on economic incentives and to increase purchasing power. The reforms also illustrate attempts to raise revenue by reducing top corporate and individual income tax rates and, thereby, broadening the base to which they apply.

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[2]U.S. Agency for International Development. "Conference Reviews Country Tax Reforms," Front Lines, Sept. 1986.